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100 Exhibition St., Melbourne, C.1.

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ARTICLES

WORLD FOOD PRODUCTION PROBLEMS

By F. T. WHALEN

To one who comes from densely populated, intensively farmed and highly industrialised Switzerland to the vast expanse of this one-nation continent, a discussion of world food problems is bound to be very stimulating. I am grateful indeed to be afforded the opportunity of participating in this symposium.

The Food and Agriculture Organisation will soon mark its tenth anniversary as an operating agency. The world has a right to turn to it in the first instance for an answer to its food problems. We have indeed made some progress towards an inventory of the world's renewable resources. We are in a better position also to appreciate the pace with which technical progress may march forward in different economic, social and cultural environments. A great deal of thought has also been given to the improvement of the machinery of distribution. And yet it would be wrong of me not to state at the outset that we do not have all the answers. Agricultural production is not merely a matter of climate, soil and water, plant and animal genes, fertilisers and management. Neither can population trends be gauged mathematically. Both depend so much on the irrational behaviour of humans, as individuals and collective society, that prophecies are risky. Pessimists and optimists both can marshal facts in support of their attitudes. My contribution to this symposium is intended to be an objective examination of the various parts of this huge problem.

How Many People Will There Be To Feed?

The following rough approximations give an idea of world population trends over the last 250 years:

Around	1700	— 500	million
„	1800	— 775	„
„	1900	— 1570	„
„	1950	— 2400	„

The present rate of increase has never been equalled in the history of man. Contributing reasons are the increase in the birth rate in many highly developed areas, the great contribution of medicine in the fight against killing diseases and in the reduction of infant mortality, and the prolongation of the average life-span expectancy. The first-named factor has been a surprising phenomenon in many advanced countries in the period 1930-1950. After some decades of reduction, which led to the slogan "The suicide of the white race," the birth rate rose again, contrary to the expectations of demographers and statisticians. In the most recent years, birth rates have been somewhat lower in Western Europe than in the immediate post-war peak, though higher than in the 1930's. In North America they remain high. It is interesting to note, for instance, that the population of the North American continent is increasing yearly by 3 million. Sweden is a good example of the reduction of infant mortality in advanced countries. During the period 1930-1950, infant mortality was reduced from 54.7 to 20.5 per thousand. Higher life expectancy as a contributing factor is well illustrated by the case of France, where 15 years were added to the average life-span between 1900 and

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F. T. WAHLEN, M.D., Honoris Causa (Zurich), is Director, Agriculture Division, Food and Agriculture Organization. *This paper was the introductory address to the symposium on "World and Australian Food Production Problems," Section K, A.N.Z.A.A.S., held at Canberra, January 13-20th, 1954.*

1950. Less advanced countries differ only in degree. In Ceylon, for example, the birth rate has risen slightly since 1930, but the death rate has been halved from 25.5 to 12.6 per thousand, and infant mortality from 174.9 to 81.8 per thousand.

Even though exact statistical data for many countries are missing, it would seem to be a conservative estimate that the world population is increasing by about 1.5 per cent. per annum. With the total population estimated at a minimum of 2,500,000,000, this means an increase of nearly 40 million a year, or over 100,000 a day. A continuing increase at the same rate would mean the doubling of the population to 5,000 million in the next 45 years.

How Are the World's People Fed Today?

If this assumption should be correct, it may be well, before we look at the appalling task ahead of us, to check the present state of food and agriculture. This has recently been done again by F.A.O's. secretariat in a document which was submitted to the Seventh Session of its Conference in November, 1953. This paper reveals that although some progress has been achieved, conditions are still far from satisfactory. In 1951-52, the latest year for which food consumption estimates are possible, 12 countries enjoyed a calorie level—perhaps even excessive in some cases—exceeding 3,000 per day. These were Australia, New Zealand, U.S.A., Canada, Argentina, Uruguay and six countries in Northern and Western Europe. In other countries in Europe, the range was between 2,500 and 3,000, and in other Latin American countries between 2,000 and 2,400. In the Far East the range was 1,700 to 2,100. In the Near East and Africa, information is too scanty to draw general conclusions. More serious are the differences to be noted between the more prosperous and the poorer countries in protein levels. In the countries where calorie levels exceed 3,000 protein consumption ranges around 90-100 grams per day, of which 50-60 are animal protein. In the Far East, daily protein intake is 40-50 grams, animal products contributing about 10 grams. In several Latin American and Near East countries we find an intake of animal protein per day as low as 15 grams.

Taking the world as a whole, levels of production and consumption of food in relation to population are now much the same as before the war. In 1952-53, total food production was 17 per cent. higher than during the 1934-38 average, exactly matching a 17 per cent. increase in population over that period. Setbacks due to wartime destruction and disorganisation have therefore been made good, taking an overall picture, and in recent years world production has grown slightly faster than population. We should not forget, however, that this progress has been achieved under extremely stimulating economic conditions. As the last F.A.O. Conference stressed, these conditions no longer exist. Marketing problems are once again limiting production in one commodity or another in several parts of the world. It remains to be seen whether, in spite of some acceleration in the rate of application of improved methods in many of the more backward regions, the moderately satisfactory progress of recent years will be maintained.

An unsatisfactory feature of this progress is that it has been rather uneven as between the different regions of the world. In North America total food production is now (1952-53) 46 per cent. higher than before the war; in Latin America, the Near East and Africa, the increase is of the order of 33 per cent; in Oceania it is 18 per cent., in Europe 14 per cent., while in the Far East (ex China) with far the heaviest population of any region, it has only barely exceeded the pre-war level. In relation to the number of persons to be fed, production in Asia and the Far East, where pre-war consumption levels were already among the lowest in the world, is 18 per cent. lower than it was 15-20 years ago. Europe has barely kept pace.

Shifts in trade have naturally cushioned the effect of changes in food supplies from

domestic production, but they have by no means fully offset these changes. In North America, Oceania, Argentina, Uruguay and many countries of Europe, calorie levels have been maintained while the quality of the diet—and therefore its cost in terms of resources—has tended to improve. In the Far East, at the other extreme, calorie levels in several countries appear to be substantially lower than they were before the war, though slow progress is now being made.

Thus it is seen that by and large there still exists the pattern of highest increases in production in regions where nutrition has been satisfactory for a long time, while progress is slowest where it is most needed. Some examples may illustrate this point. Before the war, North America produced 17 per cent. of the world's food, with a population of only 7 per cent. of the total. For 1948-50, the respective figures were 22.6 and 7.5 per cent. The export surpluses have grown correspondingly. Cereal exports for 1950-51 for example were 23 million tons against only 9 million tons pre-war. Again, there was before the war a net import need of 600,000 tons of fats, while today there is an exportable surplus of approximately the same figure. On the other side of the coin, we have Asia and the Far East, the region with the most acute food problems. Before the war, this region was a big exporter of rice, sugar, peanuts, soyabeans and other oilseeds. The net surplus of exports over imports was about 5 million tons of foodstuffs, while today the region has a net import need of about 7 million tons. Without taking into account the population increase in the intervening time, and the need for raising nutritional standards, the rest of the world had to increase its food production by some 12 million tons in order to take care of the changed trade position of this region.

What Malthus Could Not Foresee

Whether or not Malthus' dire predictions will prove true in the end is a subject still hotly debated. For the purpose of seeing the issue more clearly, let us consider for a moment why his assertions have not yet become reality. One development Malthus did not foresee, and could not possibly have foreseen 150 years ago, is the settlement of new production areas. He did not dream of steamboats and railroads, and the consequent opening of the North American prairie and the Argentine pampas for cereal production, nor could he know that meat and butter from Australia and New Zealand would reach Europe in prime condition. However, this development has come to a certain end, because only small additional areas remain open for settlement without previous heavy capital investment. The white spots on the population maps denote, apart from everlasting snow and ice, deserts, very arid grasslands, tundras or tropical jungle. Of their production potential I shall speak later.

The second series of developments not foreseen by Malthus are the undreamed-of advances of science. To mention only a few examples—it is hard to conceive how the world could feed its present population without the contributions made by plant and animal breeding, control of animal and plant diseases and insect pests, the synthesis of nitrogen fertilisers, and by mechanisation. I have spoken of the increase in food production which has taken place in the United States. An analysis of the contributing factors has been published recently, covering the period 1920-50. It was shown that the surface devoted to the production of crops directly serving human nutrition had expanded by 15 per cent., due to the reduction in the numbers of horses and mules (mechanisation) and to the fact that the same amount of cotton can be produced on a greatly reduced surface. The average yield per acre increased by 36 per cent. The number of animals (not counting draft animals), has increased by only 15 per cent., but production of each animal unit by 46 per cent. Total production for human consumption rose by 60 per cent. during these 30 years, and production per man-power year a great deal more. Similar

figures can be produced for many other advanced regions. They show what can be achieved by a healthy, vigorous and well-educated rural population where science has sufficiently explored the environment, and where the efforts of the farmers are backed by a sound, well-balanced agrarian structure. By this I mean the whole framework of institutions and the economic and social climate in which the farmer works. It includes educational and professional training facilities, equitable and secure conditions of tenure, credit facilities and co-operatives, research and extension services, equitable prices, markets and social institutions which prevent too wide a gap between the living standards of rural and urban populations. Experience shows that it is to such regions we must look in the first place for quick increases in production. This elasticity is greatly helped by the fact that under such conditions, industrialisation is advanced to such a degree that generally less than 20 per cent. of the population is engaged in agriculture, so that industry can quickly throw its weight into an agricultural production programme by providing more machinery, more fertilisers, more pesticides, etc.

The question then is how quickly can we make available the knowledge and experience of the advanced countries to what are now generally referred to as the under-developed regions, and here we touch on the fundamental problem of the Programme of Technical Assistance for Economic Development.

The Exploration of the Physical Environment

During the period of intensive colonisation of the new continents, settlers paid a heavy toll in effort and misery because of insufficient knowledge of their new environment. They took along with them not only seeds and livestock, but also their traditional methods of husbandry, and they failed initially more often than they succeeded. Perhaps too many of us, motivated by an idealistic optimism, are prone to forget this lesson of history in expecting revolutionary results from technical assistance. Technical assistance is not merely a matter of transferring into new surroundings methods and know-how developed somewhere else. There is need for a great deal of scientific exploration and research before safe advice can be given.

Take the question of soils. It has been estimated that about 1,100 million acres of tropical soils, and 300 million acres of podzols on the northern fringe of settlement could be added to the crop area. Experience has shown, however, that the tropical soils are by on means the bonanzas of fertility their luxuriant vegetation might lead us to think. In fact, the soils now cultivated successfully in the tropics are mostly alluvial or of comparatively recent volcanic origin, while the big expanses of strongly leached lateritic and red soils will require cropping systems and methods of fertilisation yet to be evolved. It is easy to condemn shifting cultivation, but difficult to put something better in its place. The northern podzols present fewer problems, thanks to more extensive experience, but their poverty and the shortness of the growing season limit their potential contribution. Both soil types will require very heavy fertiliser applications. Fortunately, the world need not be apprehensive for a long time to come about its fertiliser resources. In the case of nitrogen, the only limit is the quantity that can be used economically. For phosphoric acid and potash, recent estimates show that known supplies will last for 2,000 and 500 years respectively at an ever-increasing rate of use, and undoubtedly new deposits will be found.

In addition, there is the reserve of land which can be cropped after reclamation, both by irrigation and drainage. Asia has shown the way to a sustained system of intensive agriculture on the basis of wet paddy, and that this system is greatly capable of expansion has recently been demonstrated both in the French Camargue and in remarkable developments in

this country. In all these efforts, the stress will have to be laid on integrated economic development schemes, in which climate, land, water and people are in balance.

Higher Yields on Surfaces Now in Use

Important as the contribution of new lands may be in the future, much more can be expected of increased yields on land already in use. Much has been said and written during the last two decades about soil depletion through exploitive types of agriculture, soil erosion and careless farming in general—and rightly so. Not enough has been said, however, of the originally poor or indifferent soils which have been built up to a high degree of fertility through careful peasant husbandry over the centuries in such regions as Western Europe and Japan. Australia too presents a striking example of soil transformation by the relatively simple expedient of adding minor elements. It is safe to say that for the far greater part of its agricultural surface, the world is still in search of a permanent, stable system of agriculture. This means first of all a sound, fertility-building rotation, where rotations are practicable. In many cases this includes an integration of crop and livestock farming, which has been achieved so admirably in certain parts of Europe. To achieve this where it is most needed, the formidable handicaps to livestock raising in the tropics will have to be overcome. Our conservation problems will be solved only when conservation practices are so much part and parcel of good husbandry that no one need speak any longer of soil conservation as such.

In the pastoral economy, so important in this country, much the same applies, *mutatis mutandi.* If you cannot have rotations, you must have different categories of plants simultaneously on your land in order to build and maintain fertility, and that in the case of pastures means grasses *and* legumes. The search for legumes suitable to the varying climatic, soil and management conditions is of the highest importance. I suggest that the search for a new term indicative of this need, and supplanting the present one of "grassland farming" might have suggestive value. Another substitute for rotations on grazing lands is alternate grazing in its various forms.

There is no need for me to stress, before this audience, what all the other branches of agricultural sciences could do to raise yields on the basis of the few principles of land use just mentioned. Nor would it be possible to estimate the total production potential of the world by adding together the increases which seem feasible as a result of the more general application of scientific progress in the different branches of scientific endeavour. One way of gaining an appreciation of potentialities is by comparing average yields per acre or per animal in different parts of the world, although of course such comparisons can only be made correctly between regions of comparable climate and soils. More convincing are comparisons between farm outputs in the same county or the same township, and such comparisons show strikingly how far practical application lags behind actual scientific knowledge even in advanced countries.

Another measure of what can actually be achieved is furnished by some old settled, densely populated countries. Perhaps not many in this meeting realise that mountainous Italy, with a land surface of less than 5 per cent. of that of Australia, and about 10 per cent. of that of Argentina, produced this year a wheat crop of 8.8 million tons against 5.5 million tons by Australia and 7.2 million tons by Argentina. Her production of all cereals combined was 13.1 million tons, compared with 7 million tons for Australia. Aggregates of total agricultural production, as obtained by using F.A.O. production indices, show that the volume of agricultural production in Italy is substantially greater than in Australia, although nearly 40 per cent. even of the "productive" area is mountainous and more than 40 per cent. hilly. For 1952-53 the figures, expressed in millions of some-

what meaningless pre-1914 gold francs, are 2,931 for Australia and 4,142 for Italy.

Another fact which provides food for thought is Africa's present contribution to world food production. This continent covers 20 per cent. of the globe's land surface, but produces only about 5 per cent. of its food. Admittedly, there is the Sahara, there is the tse-tse fly, and there was the groundnut scheme. But as we know more of the African environment, the potentialities of this continent will assume much larger proportions. We must think also of the vast stretches separating continents—the oceans. Today they supply, along with inland waters, not more than 1 per cent. of the world's food needs. Undoubtedly they are capable of a much bigger contribution. We may one day fertilise fjords and inlets, as we today fertilise fishponds, and extract unbelievable fish harvests. Science has many other secrets in store. We may be led to make use of the greatly superior assimilation power of some algae. Yeasts and other micro-organisms may become crop plants, as have certain species of Penicillium. I shall not speak of synthetic fibres, which free for food crops areas now devoted to fibre plants, or of detergents, which save fats and oils for human consumption, because their role will end as we finish up our reserves of coal and oil. The first-mentioned examples, on the other hand, are truly renewable natural resources.

Such facts, figures and outlooks are surely comforting. They leave little room for Malthusian panic. For a long time to come, a greatly increased world population will find the physical basis for its nutrition, by merely applying more generally our present knowledge. In the meantime, science will march forward at an accelerated pace. We must have confidence that each generation will be capable of solving its own problems.

Science Alone Cannot Do It

We have just mentioned the physical basis of nutrition. This is only one side of the picture. How humanity will handle its political, economic, social and cultural problems is another story, and one which lies largely outside the scope of my contribution to this symposium, since our theme is world food production. However, production does not take place in a vacuum. It is influenced by incentives, by marketing opportunities, by trade conditions. It may be permissible, therefore, to add a word on the question of food distribution. The Seventh Session of the F.A.O. Conference had this problem very much in mind. In spite of the still unsatisfactory overall food situation, many countries are troubled again by surpluses. In three weeks' time, a consultation will take place between the U.S. Government and F.A.O. on the problem of how to get rid of surpluses without disturbing world markets and therefore hampering production in other countries. This recalls former attempts by F.A.O. to create a mechanism for this purpose, the World Food Board and later the Commodity Clearing House. These attempts have failed, because the problem is an exceedingly complex one, and because governments are as loth to give up any sovereignty in matters of international trade as in any other field. A good illustration of the complexity of the problem is furnished by the present surplus situation in milk, and this example also illustrates well the close inter-relationship between production and distribution.

Let us first examine why there are milk surpluses in some countries. It is not because the number of dairy cows has increased. In fact, there are some four million less than pre-war. On the other hand, average milk yields have increased between 10 and 23 per cent. in some leading dairy countries, on a world average of 8 per cent. But this cannot be the reason either, because during the same period, world population has gone up 15 per cent., and consumption of liquid milk has increased much more. According to our figures, consumption in 16 countries which together produce 75 per cent. of the world's milk has risen from 45 million

tons pre-war to 58 million tons in 1950. Thus the key to the situation lies with the milk for manufacture of dairy products. While cheese production has at least held its own, and the manufacture of preserved milk, cream and other products has increased, there is a great reduction in the use of milk for buttermaking. Butter is on the regress because of its high price and because of the competition of tropical fats and oils. In Europe, net butter imports declined from 300,000 to 200,000 tons.

The most astounding fact, however, is the increase in world trade in condensed and evaporated milk, and particularly dried milk, and the pattern of this trade. Milk powder exports rose from 30,000 to 240,000 tons, and they went primarily to the under-developed regions of Latin America, Asia and Africa. Thus, the tropical regions are beginning to exchange their fats and oils for the much-needed milk proteins. Making use of this trend, it would seem easy to dispose of surpluses by exporting milk powder to the under-developed regions at subsidy prices, or to give it away through such agencies as U.N.I.C.E.F. This the U.S. could do; in spite of being the largest producer of dried milk, its surplus is of rather marginal importance in relation to the total production. But in doing so it would hurt vital interests of the other three exporters of dried milk (Australia, Netherlands and New Zealand), whose dairy farmers would rightly resent this as dumping. But it would also defeat the long-term programmes now under way in tropical countries to build up, with the help of such agencies as F.A.O. and U.N.I.C.E.F., a local dairy industry. The import of condensed, evaporated and dried milk is invaluable for the purpose of introducing milk into diets where it had no place before, but it is no solution in the long run. Thus answers must be found to the surplus problem which do not harm the long-range interests of producers, and which have a positive effect in the formation of consumption habits, and the raising of consumption standards in general. As time goes on, international agencies like F.A.O. will become indispensable in helping to find such solutions, which can only be worked out on a multilateral basis, each interested government making its specific contribution by way of correlated production, price, consumption and trade policies.

Conclusion

In conclusion, it can be said that the scientist, in his field, has a fairly straightforward answer to the question as to whether the world can feed its people for the next generation. From his standpoint, the answer is an unqualified yes. The doubts one must harbour lie in other spheres. There is a difference between the technically feasible and the economically profitable. And there is the vast gulf to be bridged between what is known and what is practised. The immediate task ahead of humanity seems to be one of education in the broadest sense. Education not only in professional training and in the sense of extension work, important as they undoubtedly are, but education also in the sense of civic responsibility, of broader understanding, of universal outlook, of the brotherhood of mankind. For a family of nations living and working peacefully on the basis of these concepts, the world will never be too small to afford plenty for all.

THE ASSESSMENT OF SOIL POTENTIAL IN AUSTRALIAN AGRICULTURE

By J. K. TAYLOR

We will all agree that Australian resources should be assessed and that of them the soil is of paramount importance. We will all agree too that the only way to assess soils is through a soil survey. We may not agree on how this should be done, but it must be done as we are preaching to all underdeveloped countries. Australia is well within the category of underdeveloped countries and we have to face it as well as the urgent fact that it cannot stay too long in this category. But the adequate soil survey of Australia is a colossal job though we have not done so badly in beginning it. How fast we should go, or can go, are matters to be worked out, and between scientists the methods must be agreed on. I do not propose to argue now the case for an assessment of soil resources, for a soil survey plan or on techniques.

There are two basic considerations regarding our soil environment. The first is that a large proportion of our soils are of inferior quality with quite extensive areas of very low fertility. Up till relatively recent times we just avoided this problem in land utilization more particularly as for wool production the low rainfall areas were still important and for such conditions low fertility plays a far less significant role than where sown pastures and cropping are concerned. The real point of soil deficiencies has come to the front with the demand for new land settlement and for higher and cheaper production per acre. It is the scientists' business to see how to deal with developmental problems and the whole community is interested in the most profitable use of the land. This is the aim behind the soil survey. We do not do soil surveys for academic reasons at all—we do them for the better use of land.

The second feature to be emphasised is water. This symposium might well have included a paper on climatology with special reference to water as it plays such an outstanding part in our agricultural economy. Water shortage has driven us to develop poor soils with good rainfall rather than better soils without it. We never condemn any soil in absolute terms if water is available. I doubt if there are many less attractive soils than in some areas of the South East of South Australia which have little beauty in themselves except to the academic pedologist but they do have 16-18 inches of reliable rainfall sufficient for sown pasture with correct management. Irrigation has turned the unstable incoherent sands of the Mallee ridges in the Murray Valley into excellent citrus orchards. Water is then the real key to how far we go in developing soils — the infertility and management and stock problems all will yield to research.

Soil Mapping

The only soil map of Australia we have is that of Prescott, last revised 10 years ago. It is on too small a scale, the categories need redrafting, it was perforce interpretative from pieced together data, but it stands as the current map. The C.S.I.R.O. Division of Soils and State agencies are busy on a new production.

The record of how far we have gone in mapping soils is given in Figure 1 and in the statistics below. The distribution of surveys favours southern, or even

J. K. TAYLOR, B.A., M.S. (Calif.), B.Sc. (Agric.), is Chief of the Division of Soils, C.S.I.R.O., at the Waite Institute, Adelaide. *This paper was delivered before the symposium on "World and Australian Food Production Problems," Section K, A.N.Z.A.A.S., held at Canberra, January 13th-20th, 1954.*

more, south eastern Australia. Little survey has reached the arid zone as yet. To differentiate the types of mapping I have classified them on the map as—

Detailed Classes I and II.
Reconnaissance Classes I and II

Naturally there is considerable difficulty in placing some units in an undisputable class. The progress to date is given in Table I.

TABLE I.

Area covered by Soil Surveys in Australia at 30th June, 1953.

Detailed Class I	Detailed Class II	Reconnaissance Class I	Reconnaissance Class II
Sq. m.	Sq. m.	Sq. m.	Sq. m.
7,954	19,338	97,889	227,125*

*Mapped in North Australia.
Note:—The agencies concerned in mapping are C.S.I.R.O., State Department of Agriculture and Conservation in Queensland, N.S.W., Victoria and Western Australia and Universities of Sydney and Melbourne.

There is a little more to this statement than the bald figures, the magnitude of which may not impress so much, in columns 1 to 4. The more detailed surveys made in a region provide a key to understanding the occurrences of soils more widely. When we began surveying in the Murray Valley every unit was a research piece. But there is now such a body of knowledge built up that a skilled pedologist can assess virgin country for irrigation with considerable accuracy. He knows from the run of the land, its relation to the river course, sometimes the vegetation and various surface observations, what to expect—the full details of course come only by survey. Likewise in the Riverina a skilled worker basing his judgment on accumulated experience from surveys can go a long way in sorting out country for irrigation in a broad way. The South East of South Australia from three sets of surveys is similarly now open to rapid interpretation. So the relatively meagre thousands of square miles shown are an essential basis for the wider reconnaissance which without them just could not be done effectively. For country which will not be developed more intensively for a long time, if at all, the reconnaissance is an obvious approach; for the land which can and will be developed more intensively the surveys must be based on detailed work.

In considering the rate at which Australia can be mapped according to different types of surveying, we may use some approximate estimations of working speed per field party per working year.

Detailed Class I surveys—intensive development such as irrigated horticultural land, say 15,000 acres per year.

Detailed Class II surveys—somewhat broader irrigation surveys or land used at moderate intensity, 50,000 to 75,000 acres.

Reconnaissance Class I surveys—large-scale mapping in broad soil groups for general assessment of regional areas—variable rate depending on country, but say 20,000 square miles.

Reconnaissance Class II surveys—wide reconnaissance—variable rate depending on country, but say up to 50,000 square miles by a team of workers.

With these yardsticks which are approximations and may perhaps not be agreed with by all working surveyors, it is clear that mapping Australia is no small or rapid task especially as the types described under detailed surveys are the principal forms to be used for the vast areas over the 15 in. rainfall line in southern Australia. At present the gross number with any degree of skill and competence in all this work in Australia is about 40 men.

Let us go back to the soil map of Australia and superpose key isohyets. South of the tropic the 10 in., 15 in. and 20 in. and north of the tropic essentially the 30 in. limits are significant. Somewhere about the 15 in. line in the south lies the limit of cereal and sown pasture. The soils follow the isohyets quite well, though climate should not be thought of as the over-riding factor affecting soil classification. Above 20 in. in southern Australia

Figure 1.
Distribution of Soil Surveys in Australia at June, 1953.

the dominant formations are the podzolic and black earth soils which are at present essentially grazing areas. Between 20 in. and 15 in. lie the red brown earths, which are the backbone of the wheat belt in south eastern Australia, some grey and brown soils of heavy texture typical of the New South Wales south western plains, the solonetzic soils, and in Western Australia various ancient soils of a former geological climate all variably suitable for cropping or sown pasture. Between 15 in. and 10 in. lie the main great sweep of alluvial plains of grey and brown soils, those called brown soils of light texture and the solonized or mallee soils. Without irrigation these are of use only for grazing of variably sparse character. Below 10 in. are an array of arid formations moving into the desert proper; most are used for sparse grazing only. North of the tropic we may consider only the zone with more than 30 inches as the only significant area for greater development and this contains mainly mountain country, relict soils of low fertility, some podzolic and red limestone soils, needing more exploration. We must think in terms of areas of tens of thousands of acres if the north is to rise agriculturally other than through limited intensification on pastoral lands.

Lines of Investigation

I should like next to say something of the work and problems ahead in the assessment of soil resources. We might think of them under five heads, viz.:

(1) Soils of the reliable rainfall zone of Southern Australia
(2) Irrigation soils
(3) Saline soils
(4) Arid Zone soils and
(5) Tropical Zone soils.

Reliable Rainfall Zone.

This includes areas in southern Australia with 18 in. or more of reliable rainfall. Fifteen years ago large areas were virtually unused due to infertility. Researches have shown how to develop them for sown pasture by using singly or in combinations, molybdenum, zinc, copper, cobalt, sulphur, calcium, with heavy additions of phosphorus. In these podzolic and solonetzic soils we know how to push up production 3 to 15 fold in a matter of a few years. We should know more precisely where these different soils occur according to their specific deficiencies and how the application of this knowledge can be best made. It is not enough to use generalities, to say that in certain parts of South Australia or Victoria you must use copper or molybdenum. Soil surveying is a necessary thing to allow the precise application of present and future knowledge. What is even more to the point is that many research workers feel this fertility problem may not yet be finally solved. Development may bring in its train new problems in perhaps 5 or 10 years' time—animal, plant or soil problems. Much of the country being tackled is extremely low in plant and animal nutrient resources due to the history of soil formation and sometimes erosion. We have been too used to assuming addition of phosphorus and some trace elements is the complete answer; there is much more to the problem. The agronomist and the chemist have to come critically into the further investigation.

Irrigation Soils.

The engineers have assessed the maximum volume of water available for irrigation. Where it should go and how it should be used turns on the soil survey and the land classification developed from it. This has been well recognised in recent years in most quarters and active mapping has gone on in south eastern Australia. Before further development occurs this scientific assessment should be completed. But the soil surveyor has not yet all the information needed for land classification and a considerable amount of investigation must go on into soils and their irrigation values and other potential problems before we can properly move from the soil map to land classification. And here I would like to emphasize there is no sound basis for this land classification other than the soil survey. Let there

be no doubt among irrigationists and others in Australia that the only sound basis for capability classes is the classification of soils by orthodox survey methods. We do not yet know enough about soils of irrigation lands and studies in the physics of the soil and crop-soil relationship must go on *pari passu* with soil classification and mapping.

Problem of Saline Soils.

Saline soils appear under both irrigation and rainfall conditions. Most of us are aware of the increase in salinity in many irrigation areas in the Murray Valley and Riverina of New South Wales. The reasons for greater natural salinity and proneness to salting are not clear and the study of this is fundamental to assessing the soils of new irrigation areas in advance. Where we can recognise dangerous soils from experience such as in the lower Murray Valley, it is easy to design land use or install drainage if economic.

The saline areas elsewhere in Australia produced following agricultural development have not yet been studied closely but the whole problem of watertables and salt accumulation in the valley system of the Western Australian wheat belt calls for investigation. Assessment of usability or reclamation, rests on observation by the surveyor and, as a basis for field interpretation, he would like to see research testing theories on causes of salting and its progress in development or amelioration. Some very interesting changes for instance have been occurring in 15 in. rainfall country near Esperance, Western Australia, where the salinity status seems improving under sown pasture with suitable management practices. This is the kind of key necessary for the soil surveyor's work in assessing potential over wide areas.

Arid Zone.

There has been a tendency to write off the dry areas or those with much less than 10 in. rainfall. This zone is certainly not what it used to be, but I feel it may have a better future than many seem willing to concede and that a better attack on its problems is justified. The so-called marginal lands, some of which were once plowed for wheat, have surely better prospects if they were studied. At any rate this large belt of soils needs assessment in the light of exploration and experiment and on the ground of soils, erosion, hydrology, natural and introduced vegetation and management. But we must start from the soil with its physical attributes and the types of land formation which may be defined in surveys. How far this work reaches into the desert has to be decided after a start has been made on the less unreliable marginal and submarginal fringe.

Tropical Areas.

Lastly the tropical areas have to be given more thought, principally the portion receiving more than 30 in. rainfall. The C.S.I.R.O. Land Research and Regional Survey Section has covered considerable areas in Northern Australia from the Kimberleys to the Gulf of Carpentaria in a broad reconnaissance, and a few soil formations have been picked out for further examination. The wide reconnaissance does nothing more than that, but for such sweeps of country it is the right approach, sorting out and defining for further study the possibly promising formations. Soil is only one factor in this environment and the agronomic and climatological considerations are more significant than in the south. The assessment of potential development of the selected soils is a task for the future. In this I do not think in the first place we should let social or economic aspects affect the study of the problem as a scientific problem in its own right. The move into any further development can only come obviously with the fullest even pre-eminent consideration of these other factors. But let us see if there is a scientific solution possible first.

These five lines of investigation are all part of any proposal for assessment of soil potential in Australia. The work is

all based on field and associated chemical and physical studies of the soils backed up with the investigations in other branches of science. It all adds up to sound land classification and this is the duty of the soil surveyor in co-operation principally with agronomists; i.e., for the correlation of soil groups, of any breadth of definition from soil types to soil families, with land use and potential agricultural development. This correlation leads to practical land utilization. The assessment of soil resources at present in view should grow to include a system of land classification tied in with potential land use. There is a tremendous amount to do.

BOOK REVIEWS—

"BACK CROSSING". THE THEORY AND PRACTICE OF THE BACKCROSS METHOD IN THE BREEDING OF SOME NON-CEREAL CROPS

By MARY THOMAS

(*Commonwealth Bureau of Plant Breeding and Genetics Technical Communication No.* 16, 1952, *pp.* vi + 137. *Obtainable from the C.A.B. Liaison Officer at* 314 *Albert Street, East Melbourne, C.2. Price* 18/9).

Although it is generally agreed that genetics gained much from plant breeding during the early years of its development, doubt has often been expressed as to whether that science is capable of repaying the debt that it incurred. However, reference to the results of the investigations discussed in this publication leaves little doubt that the debt will soon be repaid; for here are many examples which illustrate how, in certain circumstances, one may profitably replace the old empirical rule of thumb methods in favour of more effective techniques which are based on sound genetical theory. In such cases breeding programmes may frequently be speeded up and, at the same time, pursued with a greater assurance that they will be carried through to successful conclusions.

Disappointment will no doubt be felt by some workers when they find that the publication is restricted in its scope to four crop plants — cotton, tobacco, tomato and potato. The issue of a second communication dealing with cereals and other crop plants would be welcomed by workers in this country.

In its essentials the theoretical basis of the backcross procedure is simple and straightforward, but it is disappointing to find that chapter one consists of less than three pages devoted to the discussion of the underlying theory. From what follows in subsequent chapters it is clear that many new and varied problems have arisen when breeders have sought to apply the method in practice. These issues are often of such fundamental importance to both the breeder and the geneticist that it is a pity that they have not been gathered together and discussed in chapter one. It is to be hoped that they will receive the attention they deserve in future texts on plant breeding.

In each of the following four chapters on the practice of backcrossing greatest emphasis has been given to the breeding of disease resistant varieties and especially to the transference of resistance by interspecific hybridization. Insect, nematode and frost resistance are dealt with and there are several examples of the transference of physiological and morphological characteristics.

There are few cases of repetitive backcrossing of the kind made classical by Briggs and his colleagues in California.

The literature has been well covered and, because so many of the periodicals are relatively inaccessible, each title is also referable to its abstract in Plant Breeding Abstracts.

Unlike earlier technical communications this volume is presented in a stiff covered octavo form.

THE INFLUENCE OF NUTRITIONAL FINDINGS ON THE UTILIZATION OF THE WORLD'S FOOD RESOURCES

By F. W. CLEMENTS

In 1941 Lord Boyd Orr wrote, in an article on nutrition and human welfare, "The production and distribution of food must be based on the nutritional needs of the people" (Orr, 1941). Most nutritionalists, agriculturists and even politicians would agree with this.

The acceptance of this principle raises the questions: What are the nutritional needs of people? — needs for what?, for optimal health? or "for average requirements for maintenance and growth and to furnish a margin for safety as well"? Is there a difference between these two? How is it measured clinically?

Today nutritional requirements are expressed in calories and nutrients. For every day usage, be it for the agricultural economist or the housewife, these must be converted into foodstuffs. What kinds of foods? Who shall determine the kinds of foods? What is the significance of the values which determine the ultimate selection of food by the individual and by groups?

These questions range through a number of disciplines and I see my task today as an attempt to bridge the gaps between fundamental nutritional research, human physiology, cultural anthropology and sociology.

I. Nutritional Requirements

It is probable that a relationship between food, health, and disease was recognised in ancient times if the right interpretations have been placed on the Ebers Papyrus of 1600 B.C., certain Chinese writings of about 1500 B.C. and those of Hippocrates; the efforts to prevent scurvy by dietary means from the middle of the 18th Century are known to every school boy. However, it was not until the middle of last century that the Privy Council requested Dr. Smith, the medical advisor to the Council, to specify the daily food requirements of men and women in terms of the foodstuffs of the day or more specifically of the foods commonly eaten by the poorer classes at that time (Smith, 1863).

With each advance in knowledge the lists of nutritional requirements have been modified and enlarged, first in terms of foodstuffs commonly eaten in the country where the list was developed; then in 1941 came the Recommended Dietary Allowances of the Food and Nutrition Board of the National Research Council of U.S.A. which were expressed in calories and nutrients. Since that date the original list has been modified and other national bodies (the B.M.A. in England, the National Nutritional Council of South Africa, and the Canadian Council on Nutrition) have brought out lists also expressed in calories and nutrients with distinctions for age and sex.

The leadership taken by a national body in the U.S.A. in the development of lists of human nutritional requirements based upon the newer knowledge of nutrition is of the greatest importance. Priority and prestige (both national and professional) have combined to give these tables an international standing and have

F. W. CLEMENTS, M.D., B.S., D.P.H., D.T.M., is of the Institute of Child Health, Sydney. *This paper was presented at the symposium on "World and Australian Food Production Problems," Section K, A.N.Z.A.A.S., held at Canberra, January 13th-20th, 1954.*

significantly influenced thinking on nutritional requirements throughout the world. Although a number of countries have produced lists of their own, many more refer to and generally use the American figures.

For these reasons it is important to review conditions existing in the United States prior to the development of the Recommended Dietary Allowances in 1941. Before the war there had been large agricultural surpluses and a number of plans, including the Stamp Plan and school lunch programmes, had been developed for the utilization of these surpluses. There still lingered in the minds of many people the memories of the destruction of unmarketable but needed surplus food during the depression. Also by 1941 food rationing based on human nutritional needs had been introduced in England.

About this time biochemists had devised tests to measure the degree of tissue saturation in the human body for thiamin, riboflavin and ascorbic acid. Biochemists and later clinicians were stressing the need for levels of intake of nutrients which would maintain tissue saturation. No one then or since has clearly demonstrated why such is necessary.

These two forces were strongly represented on the committees which determine the Recommended Dietary Allowances. The representatives of the Department of Agriculture constantly pressed for the highest levels of intake, particularly of nutrients supplied by foods likely to be in surplus supply from time to time, and they found evidence to support their claims in the new work of the biochemists. Thus it was that figures were set for calcium, ascorbic acid and thiamin which many workers have subsequently considered too high.

The fact that these Recommended Dietary Allowances would almost certainly be used to plan diets of the members of the armed forces, if America went to war, had not been overlooked by the committees. For this reason the committees could not leave themselves open to the criticism that the amounts were not high enough to ensure optimal nutrition of the American servicemen. In further defence of these figures it must be pointed out the members of the Food and Nutrition Board argued that the recommendations "to be applicable to an entire population would need to provide not for an average individual but for those normal persons where requirements can be expected to exceed the average."

While this philosophy is probably justified in the United States of America where food surpluses are to be expected from time to time, particularly of perishable foods, its application to the nutritional requirements of the people in countries where considerable food shortages exist is undesirable. It is true that the Recommended Dietary Allowances of the U.S.A. can be used to set goals toward which to advance in planning food production; but for many countries the quantities involved, would be well beyond the possible production in the foreseeable future. This is likely to leave the impression that however great the individual and national effort the whole population can never be nourished in a manner that will ensure optimal health. This conclusion may be quite wrong, for, as I shall show later it is apparently possible to attain satisfactory health on food intakes much below the Recommended Dietary Allowances.

A full discussion of recent advances in our knowledge of nutritional requirements should include calories and all nutrients. However, time does not permit this, so I propose to illustrate some of the points I made earlier by discussing calorie and protein requirements. In making this selection I am mindful that an adequate intake of calories ensures individual satiety with all that this implies psychologically, physiologically and socially. If calorie and protein requirements are satisfied the requirements of a number of other nutrients are generally met also; further the provision of an adequate supply of calories and protein re-

presents the major task in food production.

CALORIE REQUIREMENTS.

Keys (1949) has remarked that the philosophy of "a goal of plenty for all plus a margin for safety may be acceptable for individual nutrients such as vitamins and minerals but it leads to dangerous folly in the case of calories"—in other words national obesity—for "where economic circumstances permit, obesity from over-eating tends to be a dominant nutritional fault in modern society" (Gastineau and Rynearson, 1947).

The figures given in most tables for calorie requirements for *moderately active* men and women are 3000 and 2500 respectively.

The figure for men undoubtedly stems from the pioneering work of Voit and Rubner in the 80's of last century, and their subjects weighed 70 kg. The average weight of people in the United States of America and the United Kingdom today is about 65 kg.

Without any important exceptions the results of all recent surveys in the United States of America and the United Kingdom indicate average calorie intakes of adult men considerably less than 3000 calories. Fleisch (1947) concluded as a result of wartime experiences in Switzerland that sedentary workers required 2100 instead of 2400 calories. Numerous well conducted dietary surveys of alert, apparently healthy American women have returned calorie intakes well below 2500 calories. A few means reached 2000 calories but those for most surveys were between 1500 and 1700 calories. It was stressed that these were healthy women.

Although the term "moderately active" has been defined, it is usually in such broad terms as to mean very little in actual practice. Most people like to think of themselves as "moderately active" and when using tables of nutritional requirements most workers usually apply the figures for moderate activity, confusing this term with "average." In the latest edition (1953) of the Recommended Dietary Allowances the calorie figures have been arranged according to age. The base figures for persons 25 years of age have, apparently, been based upon the requirements of the reference man and reference woman used by the F.A.O. Committee on Calorie Requirements (F.A.O., 1950). I believe that this reference man is credited with a higher degree of activity than the average urban dweller, many of whom do little or no walking and spend long hours at a desk or are engaged in other sedentary occupation.

The definition of the reference man is: He is "25 years of age. He is healthy, i.e., he is free from disease and exhibits a 'normal' degree of physical fitness. He weighs 65 kg. and lives in the temperate zone at a mean external temperature of 10°C. He consumes an adequate, well balanced diet; he neither gains nor loses weight. His activity is exemplified by the following average weekly schedule: in each working day, 8 hours of physical work of the type referred to below, 4 hours of 'sedentary' activity (e.g., reading, writing), a walk of 5 to 10 km. on the level, and at least 2 hours out of doors; on each non-working day, the active pursuit of exercise and sport not of the extremely strenuous variety. The degree of activity involved in occupations in light industry driving a truck, dairy farming or market gardening or general laboratory work would represent approximately his working activity."

The degree of activity of the majority of urban dwellers is probably closer to sedentary than moderate activity, yet most people do not like to think of themselves as sedentary since this seems to imply laziness or some other undesirable quality. For this reason it is likely that people will demand that they be assigned more calories than they really need. This aspect of the problem will be elaborated in Part II.

The differences between the theoretical calorie requirements and the actual calorie consumption found in almost all dietary surveys could in part, at least, be

explained by the activity factor. It is absurd to conclude that because the calorie intake of groups of people in countries like Australia, U.S.A., and many European countries is below the Recommended Dietary Allowances they are undercaloried or suffering from malnutrition; it is more reasonable that the figures for calorie requirements are too high for the particular group.

Recent studies have shown that the calorie requirements for activity, the factor most likely to vary, are proportional to body weight—that most of the extra calories required for activity are used in moving the parts of the body about. Weight then is important in any consideration of calorie requirements and particularly is this so when computing the calorie needs of a national group. Other factors which affect calorie requirements are age, which usually controls the amount of activity and external temperature.

The composition of a population will materially affect the total calorie requirement, the larger the percentage of children or older people compared with the numbers of men and women 20 to 35 years of age, the lower will be the figures. A recent study by a committee set up by F.A.O. (1950) to study calorie requirements showed the following differences in calorie requirements for a number of countries:—

Country 1. Adult male 50 kg, adult female 40 kg. Environmental temperature 25°C: 30% of population less than 13 years of age—mean requirements per day 1860 calories.

Country 2. Adult male 65 kg, adult female 55 kg. Environmental temperature 10°C: 19% of population less than 13 years of age—mean requirements per day 2269 calories.

Country 3. Adult male 70 kg, adult female 60 kg. Environmental temperature 5° C: 13% of population less than 13 years of age—mean requirements per day 2390 calories.

Here is a range of over 500 calories per person per day; or if the figures used for country 3 were used to calculate the requirements for country 1, it would involve an augmented calorie production of 28 per cent.

We need a great deal of information about local conditions before the calorie requirements of each national group can be calculated with this degree of accuracy. Much of this information is not available for the people of many of the so-called underdeveloped countries.

Before considering the sources of calories I will discuss some aspects of protein requirements for in certain circumstances proteins can be an important source of calories.

PROTEIN REQUIREMENTS.

Early German work had suggested that the daily requirement of protein for an adult male was 120 g per day (an amount commonly eaten by many Australian men today) and that it could be either animal or vegetable. About 1900 Chittendon in America maintained men in nitrogen balance with 30 g per day, but there is now some doubt about his experimental evidence.

The figure most frequently quoted today is 1 g per kg body weight. The origin of this figure is not clear, but it is probably from the Royal Society Committee, which in 1919 suggested that "a diet adequate in energy value would supply sufficient protein, but the supply for the 'average man' should not fall below 70-80 g daily." The Committee assumed the "average man" to weigh 66 kg.

Well controlled experiments in recent years (Bricker, et alia, 1945; Hegsted, et alia, 1946) have demonstrated that protein intakes of 35-45 grams are adequate for adult males. The other interesting thing is that if the staple of a diet is a cereal or a mixture of cereals which are supplemented by legumes and leafy vegetables and the diet is adequate in calories, the protein intake will be in the vicinity of 1 per kg. body weight. Studies in India (Basu and Basak, 1941) have confirmed

this. Three typical Indian diets we investigated were:—

Diet 1. A rice diet with pulses, vegetables and a small amount of fish—provided 76 g protein.

Diet 2. A rice-vegetable diet, rice augmented with pulses and leafy vegetables—provided 53 g protein (mean weight of subjects 50 kg).

Diet 3. Atta (wheat) plus pulses and leafy vegetables supplied 82 g protein.

The subjects were healthy and were maintained in nitrogen balance on these diets, demonstrating that it was possible to meet the protein requirements without the consumption of animal foods especially rich in protein.

People whose staple is a root crop with a high moisture and fibre content may not obtain 1 gram per kg of protein, even though the calorie intake is adequate.

Total protein is only part of the story. The biological value of the protein is important. Once it was taught that at least half the protein should be of animal origin; the amino acid content is the critical factor. The earlier opinion of the inferior quality of vegetable proteins was based on analyses of cereal proteins, but we have been forced to revise our opinions of vegetables as sources of protein. The proteins of pulses, nuts, some tubers and leafy vegetables have been found to have amino acid contents not significantly inferior to proteins of animal origin. It is now known that cereals augmented with pulses and leafy vegetables can provide adequate amounts of essential amino acids for maintenance.

While this fact has been fairly readily accepted insofar as adult men and non-pregnant and non-lactating adult women are concerned, the majority of workers, particularly those brought up in the Western European-North American tradition, do not seem prepared to extend the ideas to infant and child feeding. This is understandable for the Western European-North American tradition has been that cow's milk was the basis of post weaning diets. The use of cow's milk in some form as an important article in the diet of 25 per cent. of the population was made possible by the parallel development, in these countries, of the dairy industry and provision of safe, clean milk. In many parts of Africa, Asia, Central and South America practically no milk other than human milk is available. To counter this deficiency breast feeding is continued long after the breast has ceased to yield more than a fraction of the infant's requirements.

Because the supply of adequate quantities of safe, clean, animal milk is not considered a reasonable possibility in some countries, in the near future, studies have been commenced using other types of food as milk substitutes. Already much progress has been made with various combinations based on soya and more recently Dean of Uganda has produced an infant food which he believes is a satisfactory substitute for milk, based on bananas and sunflower seed cake. This work may open up a new era in which proteins of vegetable origin could substitute for the proteins of animal origin for infant and child feeding as they do in some parts of the world in the diets of adults.

These recent developments will undoubtedly call for a revision of many old cherished ideas about human nutritional requirements which as we have seen have been based on the traditions of Western civilization.

THE SUPPLY OF CALORIES.

Calories can be supplied by carbohydrates, fats and proteins and the percentage each contributes is determined by a number of factors. Physiologically the body seems able to obtain calories from all three in almost any proportions. At one extreme are some groups of Eskimos who derive 47 per cent. of their calories from fat, 44 per cent. from proteins and 9 per cent. from carbohydrates (Sinclair, 1953) and at the other end are groups

of New Guinea natives who derive 90 per cent. of their calories from carbohydrate and 5 per cent. each from protein and fat (Hipsley and Clements, 1947). Adaptation undoubtedly plays an important part in the ability of the human body to handle these big differences. As a source of calories the nature of the carbohydrate is not important; what is important is that many staple carbohydrate-rich foods which are major sources of calories often provide considerable quantities of protein and other nutrients, whole grain cereals being a good example. The importance of this is being disregarded in a number of places where attempts are being made to substitute higher calorie-yielding crops, such as manioc, for cereals; the yield of calories per acre being, at least, twice as great. Unfortunately manioc is practically pure carbohydrate.

Because fats yield $2\frac{1}{4}$ times more calories per unit weight than carbohydrates or protein, they reduce the bulkiness of food; they also increase satiety. For these two reasons they are eagerly sought after by most peoples, particularly those whose diet is habitually low in fat.

The source of fat is of no nutritional significance; fats of vegetable origin are as nutritionally available as fats of animal origin and hydrogenated animal fats and vegetable oils are as easily assimilated as butter. That some fats are carriers of fat-soluble vitamins is an important distinction but artificial fortification of fats deficient in vitamins abolishes this. The choice of butter or margarine is determined on other than nutritional grounds. This will be briefly referred to later.

As the economic status of an individual or group rises a higher percentage of calories is derived from proteins and fats. These changes are seldom made for nutritional reasons.

Conversely, many people in all cultures habitually eat diets that are nutritionally wasteful and can be classed as luxury diets. They obtain unnecessarily large percentages of calories from fats and proteins and because foods rich in these two nutrients are more costly than foods rich in carbohydrates the diets can justly be considered in the luxury class. The diets of many Australians whose protein intake is in the vicinity of 120 grams per day are in this category. It is not nutritional requirements but other factors which govern their choice.

CONCLUSIONS.

At this stage the following tentative conclusions might be drawn:

1. Requirements of calories and proteins, at least, for the average adult man and woman are significantly lower than the figures usually quoted in tables of nutrient requirements, etc.

2. Many vegetable proteins and particularly combinations of vegetable proteins provide an adequate supply of amino acids for maintenance.

3. The vegetable oils and most animal fats are of equal value as sources of energy.

4. The nutritional requirements of adults in countries like Australia could be met by a higher consumption of carbohydrates and a lower consumption of fats and proteins—this means a higher consumption of cereals and a lower consumption of meat, milk, eggs and butter. The nutritional requirements of adults in Asia and perhaps other countries can be met without any increase in the consumption of animal products, merely by ensuring an adequate calorie intake.

5. That as the socio-economic status rises there is a tendency for people to consume more expensive diets, richer in proteins and fats of animal origin. This change is determined by other than nutritional factors.

II. The Social Milieu

These few disjointed facts belong to what is now called by some writers, the "internal logic" of the nutritional and psysiological sciences. I want to spend a few minutes considering the significance of these facts in the light of the current social milieu.

During the last two decades much thought has been given to the relative importance of the "internal logic" of various sciences and the social environment in the cause and effect of scientific development. Interesting as this subject is, it is outside the scope of this paper to linger here. Lilley (1953), after reviewing the current arguments and the evidence of history asserts, dogmatically, that "any scientific development becomes possible only when both the internal and external conditions are ripe."

Sociologists now recognise that foods occupy an important place in almost every culture and that the selection of foods by individuals and national groups is governed by a number of factors. Physical availability is but one of these and cultural availability or desirability may be equally important. Lewin (1943) points out "there are many edible materials which people never even consider using." Even foodstuffs which are recognised as such for human beings may not be accepted as food for one's own family. Similarly, foods which may not have any special nutritional significance are keenly sought after for their prestige value. One food of equal nutritional value to another, for example, butter to fortified margarine, is preferred for non-nutritional reasons.

A hierarchy of values which governs the selection of food exists in every community, including cost, health value, taste and status or prestige. The relative weight accorded to each of these varies from one community to another and in the same community from time to time, these changes are often the result of outside influences. Within one society the lower socio-economic groups tend to imitate and adopt values prevailing in the higher socio-economic groups.

The food patterns of Western civilization, which has spread itself more widely than any other local group, have become more desirable than their own to many other local groups. Taste may be a factor stimulating this change; dishes based on meat and other animal-protein-rich foods are, to many non-Western palates, more appetizing than dishes based on vegetables alone. However, the prestige value of food patterns of the countries of Western civilization cannot be overlooked.

Since food enters so strongly into the cultural life of most groups, developments in the nutritional and other sciences cannot be considered in isolation. They only have meaning for us when they are analysed in the light of current international and local social environments. Many of the discoveries in the fields of nutrition in the past have been socially acceptable for they have been associated with the increased consumption of many foodstuffs which either have a high prestige value or can be prepared into appetizing dishes. The fact that the scientific advances meant eating more of something appealed to the man in the street, it enhanced his self esteem.

Much of what I have been talking about, namely, lower requirements and the wider use of foods that may have a lower prestige value will not be socially acceptable. Such changes could only be introduced in times of national crisis, as food rationing in time of war. Equally unacceptable to the great majority of people is the idea that their calorie requirements are in the sedentary category.

It is equally doubtful if the peoples in the underdeveloped countries of the world would be contented with the idea that a diet of cereals and pulses should be their fare whilst other groups can have diets which have acquired the reputation of nutritional superiority, albeit wrongly, and a higher prestige value.

At this point we enter the fields of the relatively new science of sociology from

which we require a great deal of help. We need to know much more about the values different groups of people place on the selection of food, especially in the economically underdeveloped countries. We need more accurate data on the actual food consumption patterns of the people of various cultural groups correlated with the evidence of nutritional status and physical and mental well-being.

In the meantime we will probably go on using figures for calorie and protein requirements that are in excess of actual requirements not for nutritional reasons but because the forces of the social milieu will not permit us to do otherwise.

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THE GROWER'S PREFERENCE

AUSTRALIA'S AGRICULTURAL PROGRAMME

By J. G. CRAWFORD

In my remarks I will address myself to some aspects of the following questions:

I. (a) Is there an agricultural policy in Australia?

(b) Is there an agricultural programme?

II. (a) Have we the resources to match the programme?

(b) Are we making efficient use of them?

III. Will anyone buy our produce?

IV. Where are we now and where are we heading?

I.

(a) Is There an Agricultural Policy in Australia?

Since the actions of Government must, in many matters, affect agricultural production and marketing a description of those actions may well be a description of policy. Indeed, the history of Australian agriculture in recent decades is little more than this. Except in time of war it has not been usual for Governments to draw up a policy in comprehensive terms and then to formulate legislative acts within that framework. Yet something of this sort has been done in 1952 and 1953 by Commonwealth and State Governments acting severally and in concert through the Australian Agricultural Council. The keynote is given in two extracts from a statement made by Mr. J. McEwen to the Council in February 1952:

"The Commonwealth Government has, therefore, decided to adopt as its policy objective a Commonwealth-wide programme of agricultural expansion, not only to meet direct defence requirements, but also to provide food for the growing population, to maintain our capacity to import, and to make our proper contribution to relieving the dollar problem."

"Out of a consideration of all these circumstances the Commonwealth Government has decided that activities directly concerned with the production of essential items of food and agricultural products in this country shall be classified in importance with defence and coal production."

(b) Is There an Agricultural Programme?

This policy is primarily one for production and has received expression in a number of production targets referred to below. Relevant actions taken since Mr. McEwen's statement include special taxation concessions for primary producers, steps to improve supplies of equipment and materials (including dollar loans), recruiting of labour through the immigration programme, increase in volume and tempo of farm advisory activities, and, not least, some attention to vexed questions of wheat marketing and overseas contracts. All these* may be fairly described as a programme and, as a group, have the merit of suggesting that Governments do recognise that an effective agricultural policy requires a wide range of action. Despite, however, the possible limitation set by the title to my contribution I propose not to describe the action programme in great detail. I prefer to draw attention to some underlying requirements of, and some question marks in, the policy as it is at present conceived

J. G. CRAWFORD, C.B.E., M.Ec., is Secretary of the Commonwealth Department of Commerce and Agriculture. *This article is a synopsis of his contribution read to the symposium on "World and Australian Food Production Problems," Section K, A.N.Z.A.A.S., held at Canberra January 13th-20th, 1954.*

*Many are described in the author's Joseph Fisher Lecture, Adelaide University, 1952, and in the September, 1953, issue of "National Development".

TABLE I.

Commodity	Unit	Estimated consumption 1957-58 (a)	PRODUCTION			EXPORTS			
			Pre-war average (c)	Average 1946-47 to 1950-51	Aims for 1957-58 (b)	Pre-war average (c)	Level if no increase in production over post-war level i.e. (3)-(1)	Level if aims achieved i.e. (4)-(1)	Change compared with pre-war i.e. (7)-(5)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
AGRICULTURAL PRODUCTS									
Wheat	m. bushels	91	165	186	191	106	95	100	—6
Oats	m. bushels	18	17	27	42	0.2	9	24	+24
Barley	m. bushels	13	10	19	25	3	6	12	+9
Sugar	'000 tons	513	805	792	1,228	425	279	715	+290
DAIRY PRODUCTS									
Butter	'000 tons	132	191	162	170	90	30	38	—52
Cheese	'000 tons	28	25	43	40	12	15	12	—
Processed milk	'000 tons	57	34	97	190	10	40	133	+123
Eggs (d)	m. doz.	89	80	118	129	13	29	40	+27
MEATS									
Beef and veal	'000 tons	561	569	577	672	121	16	111	—10
Lamb	'000 tons	104	118	131	190	72	27	86	+14
Mutton	'000 tons	172	201	180	213	17	8	41	+24
Pigmeats	'000 tons	68	94	91	100	14	23	32	+18
Wool	m. pounds	114	1,022(e)	1,048	1,200	964	934	1,086	+122

(a) Needs for 9.7 million people at 1950-51 per capita consumption rates.
(b) Aims set by the Australian Agricultural Council: The year is not regarded as a precise time objective.
(c) Average for 3 years ended 1938-39.
(d) Total eggs in terms of shell equivalent.
(e) Revision of published statistics.

and administered by public authorities—Federal and State.

The Australian Agricultural Council expressed its policy objectives in the form of production aims or targets. These are given, together with some other relevant data, in Table I.* Using the type of index used by the Commonwealth Statistician in recording primary production aggregates, these aims for 1957-58 (or thereabout) represent an expansion in volume of production of about 24 per cent.** over pre-war (3 years ended 1938-39) level. Allowing for growing domestic needs, this would allow about 21 per cent. increase in the volume of exports.

These aims, although regarded as modest, were set against a background of 1951-52—a bad year—when production was only 4 per cent. above pre-war. Average post-war experience was little better than 10 per cent. above pre-war. Already, however, wool (thanks in large measure to myxomatosis) and sugar have surpassed the goals set for them. Except for smaller items with exceedingly difficult production problems not yet tackled (e.g., tobacco and cotton) there is little reason to expect failure in the production programme. The production volume in 1952-53 was 19 per cent. above the pre-war basis and there was more in this than a good season. Similarly 1953-54 may, despite less favourable seasonal conditions, be 20 per cent, up on pre-war—well above other post-war years.

It is to be remembered, however, that the programme set out in these targets is a relatively short-term one. We cannot assume that Australia's economic development will stop at 10 million people. We

* Reproduced from the Joseph Fisher Lecture, op. cit., page 15.
** Calculations by the Bureau of Agricultural Economics.

must look well beyond these numbers and beyond 1957-58. It is well, therefore, to ask whether our resources are capable of doing better than the 1957-58 aims. To this question I now turn. In the course of comment on it, I may well mention matters which could limit our short-term achievements. If I do, it will also be with an eye to their longer range significance also.

II.

(a) Have We the Resources to Match the Programme?*

LAND. (i) Potential land utilization was summarised by the late Dr. A. V. Richardson in 1947. His assessment was: (a) 1 million square miles (34 per cent.) rainfall less than 10 inches per annum—either desert or very sparse grazing; (b) 1¼ million square miles (42 per cent.) sufficient rainfall to provide fair to good grazing but insufficient for farm crops; and (c) 464 million acres (24 per cent.) located on the out fringe of the continent has a length of growing season exceeding five months, and is suited to agriculture and intensive grazing. After allowing for mountainous areas and areas of poor sandy or lateritic soils in Northern Australia, some 144 million acres could reasonably be regarded as suitable for *cultivation.* This estimate of 144 million acres cultivable land compares with just over 20 million cultivated for crops in 1952-53.

(ii) More recently Dr. Griffith Davies has spoken of 300 million acres of land which, because of greater knowledge of soil deficiencies, is now capable of pasture development and hence higher fertility. Of this, some 190 million acres are in Queensland. He talks of doubling stock numbers:—"It is probably a gross underestimate to say that this new knowledge will allow us to double our stock numbers. If we assume in Victoria and New South Wales that we can carry one more sheep to an acre in addition to present stocking, this would represent 94 million in addition to the present 70 million. In Queensland a beast to 10 acres in addition to present stocking would add 19 million cattle to that State's present total of 6 million."

(iii) Both these estimates make it clear that supply of land is not in any physical sense a limiting factor on Australia's agricultural programme. Certainly the 1957-58 goals are not excessive, except probably where irrigation, as for example in cotton and tobacco, is a vital factor. Since these notes are concerned with the long pull, too, it is well to offer a cautionary word or two on Davies' estimates. Quite apart from the probability that he has under-estimated the country of too rough topography and that he admits that science has not yet found the answers to all the soil deficiency and other pasture problems, there are economic reasons for caution too. If our present 18 million acres of improved pasture require some 800,000 tons of superphosphate how much will we need for even 50 million acres? We don't know yet (and much of the soil may not require it at all), but it is certain that our present fertiliser output must be greatly expanded. Hence the importance of the programme for developing our pyrites as a source of sulphur. Fortunately the materials required are available and the problem of supply of the final product is well within our capacity. However, the growing need must be anticipated by manufactures as it now has been by Governments. The cost of fertiliser is an important item in farm establishment and operating costs and must not be ignored. Therefore research into manufacturing costs and into the most efficient use of fertilisers on farms is of the utmost importance.

LABOUR. It is normal, as mechanization in agriculture increases, for productivity per man so to rise that direct employment of labour on farms decreases—unless the total expansion in production called for by the market justifies both rising productivity per man *and* greater numbers of men. There are signs that

*A large portion of this section is drawn from an official paper recently submitted to the National Security Resources Board. Portions may subsequently be published by that Board.

Australia is entering such a period. Mechanization is proceeding apace, but numbers of persons employed on farms are up again. During 1952-53 (April 1st to March 31st) permanently employed (including owner-operators) rose by 8,000. Although at 404,000 the numbers are well below pre-war (432,000 in 1938), the increase is significant. It reflects availability of suitable immigrants, an easing of the condition of "over-full employment," and the influence of depreciation allowances applicable to the construction of employee housing and of these same incentives for using extra labour on developmental work on farms.

The greatest danger to this healthy state of affairs is a recurrence of "over-full employment." On the other hand, continued emphasis in the immigration programme on qualified rural employees would be a help. Mechanised agriculture has attractions for employees and the evident lift in accommodation standards on farms should also play a part in maintaining a steady expansion in numbers of farm employees. It is another question, however, whether the supply of new holdings will match available numbers of men qualified to manage holdings on their own account.

MATERIALS AND EQUIPMENT. A summary schedule of the position is given in Table II.

It is worth noting that it is not only in labour supply but also in the field of materials and equipment supply that "full employment" affects agriculture. So far, in the post-war period secondary industry and public works investment have, when power and steel have been short, rather beaten industries supplying agriculture in the race for the scarce items. Much has been done by negotiation with private enterprise who have responded well to special requests on behalf of agriculture, and by import policies designed to maximise supplies (albeit more costly supplies). Taxation concessions are stimulating farm demand for a great range of equipment and it is likely that the pressure on supply will be considerable for major machinery and material items for some time to come. The position has eased, but shortages persist for harvesters, galvanised iron and steel posts.

"Know-How" and Finance are important resources in which we are at least moderately equipped but some critical aspects are the subject of brief reference below.

(b) Are We Making Efficient Use of our Resources?*

Short of a detailed statistical examination this question is too difficult to answer other than in highly generalised terms. Efficiency in farm operations in Australia, whatever the test applied, is as diverse as the geographical conditions of the continent would lead one to expect. In terms of costs per unit there is little doubt that Australian wool, wheat and meat industries compare favourably with overseas competitors. This is even true of a substantial portion of the dairy industry. This definition of efficiency becomes important in the event of economic recession.

My concern here is to mention that efficiency as measured by output per man, per unit of land, or per animal unit is also rising. Other things being equal (e.g., stability of general price levels) these should have been reflected in falling costs per unit of output. If we could keep general price levels steady we could more obviously enjoy the benefits of rising efficiency standards. (One factor which obscures important improvements is rising land values which reflect not only rising price levels, but the special profitability of sheep and wool in recent years as well). In any case, total net incomes are being increased under present cost conditions by pasture improvement, fodder conservation, myxomatosis, water conservation on properties, improved wheat varieties, mechanisation, etc.

*Difficulties in handling available statistical data have impeded analysis and I think it worth stressing, in passing, that there is much room for studies by agricultural economists and statisticians of efficiency criteria and progress in Australia's primary producing industries.

TABLE II.

Materials and Equipment	Current Position	Longer Term Materials and Equipment in General
Tractors		It is practicable to meet requirements providing the necessary resources are devoted to this purpose. Importation of particular types of equipment will continue to be necessary.
Wheel, medium and low powered	Adequate	
high powered	Some shortage	
special types	Some shortage	
Crawler, all sizes	Shortage of preferred makes	
Ploughs		
Most sizes and types	Adequate	
Heavy duty	Shortage	
Special types	Shortage	
Cultivating equipment	Adequate	
Grain harvesters	Some shortage	
Forage harvesters	Some shortage	
Mowers	Adequate	
Pick-up hay balers	Shortage	
Side delivery rakes	Some shortage	
Galvanised iron	Shortage of some 40,000 tons p.a. (Present production 130 to 160,000 tons)	
Water piping	Shortage of certain sizes	
Fencing wire	Now generally adequate	
Barbed wire	Now generally adequate	
Wire netting	Shortage—perhaps 10,000 tons p.a., local production being about 16,000 tons.	
Steel posts	Serious shortage	
Cement	Local shortages	
Superphosphate	Incipient shortage	

It is important to notice, too, that while we are certainly not immune from drought, there are clear signs that in wheat planting and harvesting and in livestock feeding, improved practices are enabling farmers to deal with moderately adverse seasonal conditions more successfully than was true even a decade ago.

There is quite definitely an increased tempo in the activities of farm advisory authorities and ample evidence of the interest of farmers in new methods. This interest is vital to rising efficiency.

Factors Retarding Use of Resources.

RISING COSTS. I regard the need to curb costs per unit of output to be of great importance. Yet it is necessary to keep this problem in perspective. An economic recession in wool and wheat (the latter nearer than we wish) could well do serious damage to our export, and hence national income. It would not, however, put very many farmers out of business—such is their margin over costs. Perhaps 10-15 per cent. of exports are now in or face competitive difficulty. This difficulty is disproportionately felt in Australia because fruit (canned and dried) and processed milk (and vegetables) are associated with closely settled areas highly dependent upon specialised farming. While I urge perspective, I am

not preaching indifference to costs. Rather, I suggest it be a continual theme because increased efficiency is the real way to promote farming profits—and it is the only way effectively to retain overseas markets in those industries where prices and costs are already in close or adverse relationship.

HIGH COST OF INVESTMENT. Farm units for new farmers are expensive. Since 1945 farming has become big business indeed. Moreover, the figures for investment which are quoted below may be regarded as conservative in comparison with some current market values. A moderate wheat farm producing about 4,000 bushels and running 400 ewes now requires land, equipment and stock to the tune of about £20,000 as against £9,000 in 1945. Woolgrowing using 1,500 merino on natural pastures requires about £24,000 as against £12,000; woolgrowing and fat lambs (1,000 ewes) about £18,500 as against £9,500. Finally, dairying (50 cows) requires about £12,000 as against £6,000. All these have commensurately increased operating and maintenance costs.

The high cost of land affects the newcomer rather than the established farmer whose security value is indeed enhanced. Offsetting investment cost is the generous depreciation provision already noted. Thus the ability to write off (for taxation) the £4,000 of plant on a wheat farm in five years is clearly an important off-set to the increase in costs from £2,000 in 1946.

It is difficult to disentangle the facts about new farm units. Until the last year or two it was quite clear that the supply of new farms was inevitably restricted not only by lack of funds (especially public funds), but also by lack of physical equipment and materials for farm development. The situation now is obscured by an apparent decline in total holdings. These figures are being carefully examined, but it is thought that changes in very small holdings (one acre qualifies) mask other real changes occurring. We know the scale of public closer settlement, which is proving expensive and slower than was hoped. However, private subdivision has probably been greater than is apparent in official statistics. The scale of private investment has certainly risen smartly and it is probable that subdivision providing many new units for sharefarmers, and for future allocation to sons, is proceeding. Some abandoned holdings are coming back. All this is consistent with the increase in numbers engaged in farming and the increased mechanisation already noted. In short, it is assumed that private subdivision is recurring in keeping with the evidence of intensified farming. The movement seems particularly important in Queensland—but more precise evidence is needed.

Irrigation development is a special case under this heading. Sooner or later we must develop more irrigation facilities. The problem here is high total cost of investment rather than any suggestion that there is no agricultural or economic case for such development.

SUPPLY PROBLEMS. I would suggest that the five most critical supply needs are:

(i) Steady expansion in fertiliser supplies;

(ii) Continued but not unlimited access to dollar equipment;

(iii) Improved supply of critical materials and equipment—galvanised iron, wire netting, steel posts and headers;

(iv) More adequate supplies of people trained in agricultural sciences both at University and Agricultural College level. This is absolutely vital in the advisory and research fields. It is the paramount limiting factor in more effective spread of our agricultural "know how":

(v) Steady increase in availability of man-power for farm employment.

I have not listed credit supply as an active problem of the moment: it is not as tight as it was, and, undoubtedly, farmers in the major industries have more resources of their own than they had pre-war. This position is now reflected in rising "on farm" investment. Nevertheless, certain State credit authorities are not able to make advances commensurate with present day costs. I am not convinced that credit won't again become a special problem of considerable importance in raising productivity standards.

III.

Will Anyone Buy Our Produce?

The statement of agricultural policy by Mr. McEwen, cited early in this paper, and all efforts to expand production make two important assumptions. The first is that the volume of imports required will grow so substantially as to necessitate a marked expansion in our exports. The second assumption is that the world wants and will pay for the exports in terms adequate not merely to finance needed imports but also to sustain the output of exportable goods. It is difficult to give precision to these assumptions but the argument can be simply illustrated. If import requirement move simply with population from the pre-war level, the 1957-58 volume needed would be 40 per cent. above pre-war. If no change occurred in the pre-war export/import prices ratio (terms of trade), and if borrowing or other capital imports are ignored, then exports should rise similarly. There is nothing to suggest that imports needed will not rise by this amount. The terms of trade should remain relatively favourable to our exports—perhaps by 10 per cent. It is not unreasonable to envisage an increase of 30 per cent. in export volume (from pre-war) to finance about 40 per cent. increase in imports in the late 1950's. We have noted that the Agricultural Council targets provide only 24 per cent. increase. It is therefore well that the wool target is already exceeded.

The outlook for many primary products—more especially meats, butter, fruit and vegetables—has firmed because of rising domestic needs (see Table I). Here I am concerned principally with the world market which, despite seriously uncomfortable spots, looks consistent with the thesis that we will be able to find profitable outlets. A summary of the outlook might run as follows.

Both the long and short term outlooks for *wool* appear sound — although there may be some reduction from the present level of wool prices there is at present a comfortable margin between costs and returns. Australia as a low-cost *wheat* producer and a non-dollar wheat supplier faces a favourable long term market outlook. The domestic market for *coarse grains* is increasing and the export surplus seems reasonably assured of profitable prices. In view of the continued pressure of world population on supplies there appears to be further opportunity for expansion of *rice* production. The International Sugar Agreement provides a generally favourable outlook for the *sugar* industry particularly if cost stability can be maintained. There is a general and continuing tightness in the prospective *beef* supply position and the outlook is particularly favourable. The outlook for the fat *lamb* industry is also favourable although with major production increases anticipated some slackening in price may follow. The emphasis in increased *mutton* production should be on quality if marketing difficulties are to be avoided. The short term outlook for pigmeats is not as favourable as for other meats. The market outlook for *eggs* points to the need for increased efficiency and a reduction in production costs. The increasingly competitive nature of the overseas market for *dairy products* and consumer resistance to recent price increases in Australia point to the need for increased efficiency on existing farms rather than development of new farms unless costs can be demonstrated to be intra-marginal.

I would suggest that markets will be steadily available for the great bulk of our exports and that, while prices will undoubtedly fluctuate (and, in short periods, the terms of trade move against us), there is no need to plan the future on the basis of a 1930 depression.* The four major question marks in the future outlook are the possibility of recession in the U.S. (and U.K.), greater success in the effort to find cheap substitutes for wool, the failure of under-developed areas in Asia to raise living standards (or even maintain them for rising populations), and the possibility of further inflation of costs in Australia. There is no cause for cockiness in any of these matters. Nor, on the other hand, need we let their spectres frighten us into policies of despair.

IV.

Where Are We Now and Where Are We Heading?

The present position in agriculture is fairly clearly one of well based expansion. By "well based" I mean sufficiently well equipped with land, labour, "know how," capital equipment and materials, to be able to anticipate rising production levels. It is, likewise, not unreasonable to expect rising productivity per unit of labour, land or (given stable values) per £ of investment. Certainly, the generous tax concessions available have enhanced the outlook for private capital investment in farming. Some headaches in marketing and in production are with us; others will come: but none of them is likely to be cured by policies of "stay put" in production. Fortunately, costs per unit—so important to our competitive position—are either comparatively low already in most of our mapor industries or are capable of improvement—particularly if we continue to hold the forces of inflation.

The picture is altogether different from the miserable disappointments of 1946 to 1950, when with all the will in the world Australian farmers were unable—for lack of real resources—to produce more. If I may use the concluding remarks of a recent article in "National Development":

> "The picture has changed from one of frustration, if not of despair, to one of a real and gathering forward momentum in rural production. In this, the improved material supply position, and active Government policies are playing their part. Running through all we have noted the developing agricultural revolution. Our land resources are no longer as niggardly as they were. What this means is well summed up by an American economist, Professor Schultz, who has said: 'When the niggardliness of nature is real, and new and better production possibilities in agriculture come hard, the prospects of economic development are not bright. When technical advances in agriculture make possible a cornucopia, the stage is set for a more rapid development." The stage is so set for Australia; a horn of plenty is a practicable objective to the good fortune of our own population and to those elsewhere who need our help in peace or war.

*See Joseph Fisner Lecture, op cit., pp. 26 at seq.

BALANCING DEVELOPMENT OF NEW AND OLD LANDS IN SOUTHERN AUSTRALIA

By A. R. CALLAGHAN

Introduction

The pattern of land development in southern Australia has been determined by soil fertility and length of growing season, modified by proximity to markets or transport.

In the last century, cereal cropping was the chief form of agriculture on developed country, with the pastoral industry based on the utilisation of natural grass pasture and shrub steppe. As a result the pattern of land development was influenced more by soil fertility than by available moisture. In other words, the more fertile soils were developed, in order of regions with decreasing rainfall, while the more highly leached soils of the higher rainfall areas, which could not support continued cropping, were neglected.

This trend continued into the present century. The soils of higher initial fertility were exploited and little was done to improve the soils of low fertility. The value of these latter soils began to be appreciated as the use of superphosphate and the spread of subterranean clover increased. Spectacular increases in production resulted. Herbage production tended to be proportional to annual rainfall, and interest in land development became centred on the higher rainfall areas, most of which were near markets with arterial transport facilities available. Again it was found necessary to by-pass certain soils which could not be developed with the knowledge and techniques available at the time.

Soon after the commencement of this trend, which saw the build-up of fertility of these poor soils, came the growing realisation that the exploitive farming system which had been practised in the cereal districts had produced most serious effects on soil fertility. Lowered nitrogen and organic matter status and loss of structure and of surface soil were the chief features of this induced low fertility. With this as background, the present position of land development can be defined.

The Present Position of New and Old Land Development

New land development refers to the improvement of soil fertility—essentially in terms of nitrogen and organic matter—by the establishment of legume-dominant pasture. It is emphasised that this is and has been the only criterion for the successful development of low fertility soils in regions of longer growing season. Subterranean clover (the Mt. Barker strain) and the appreciation of the value of superphosphate for top-dressing pioneered the way. Since then a number of other scientific and technical advances have made more extensive and more rapid development possible. This latter advance has taken us from the better class podsolic soils, to those of much lower status. The main contributory factors in this phase have been in (1) the choice of subterranean clover strains adapted to a shorter growing season, (2) the use of strawberry clover on the heavy alkaline, wet soils of south-eastern South Australia, (3) research work on plant nutrition which led to spectacular responses to cop-

A. R. CALLAGHAN, C.M.G., D.Phil., B.Sc. (Oxon.), B.Sc.Agr., is Director of the South Australian Department of Agriculture. *This article was read to the Symposium on "World and Australian Food Production Problems," Section K, A.N.Z.A.A.S., held at Canberra, January 13th-20th, 1954.*

per, zinc, molybdenum and manganese and (4) the production of equipment capable of large scale clearing and ploughing of scrub land.

Old lands and their development fall into two distinct categories,

1. The management of depleted *cereal land* so that fertility is restored and production maintained at a higher level. It is again apparent that legume growth is the key to fertility build up. Fertiliser application, grazing management and cropping rotations must be adapted so that suitable legumes—notably annual medics, subterranean clover strains and lucerne—are enabled to fulfil their vital role.
2. The further development of *clover land*, i.e., the bringing to full production of land on which the primary phase of pasture development has been completed. This involves several modifications, (a) the grass: legume ratio will have to be improved, (b) the period of herbage production must be extended by using perennial grasses and legumes, (c) grazing management must be put on a sounder basis and more attention paid to ensure a high plane of nutrition throughout the year, (d) where profitable, pastures should be of shorter duration to allow cropping to be introduced into the rotation and (e) greater use should be made of supplementary irrigation during the summer to maintain special purpose pastures and crops.

The principles underlying the development of new land of low fertility and of old land where low fertility has been induced by over cropping are essentially the same. Conditions must be created to favour legume dominance and enable nitrogen and organic matter enrichment of the soil, leading to an improvement in general fertility. The restoration of structure and reduced liability to erosion losses are important features in the over cropped and over cultivated cereal soils.

The development of old land which has supported good clover for some years is basically different. Soil fertility must be maintained at a safe level but, with this limitation, the maximum return must be obtained from the land. This involves the full use of nutrients and moisture in growing crops and pastures and the proper utilisation of herbage by the grazing animal.

In summary, it may be said that both phases of development are taking place as a result of (1) favourable economic factors since the War, (2) new scientific knowledge of the factors limiting development and production and (3) advances in agricultural machinery.

On most existing farms there is still a latent potential of production which can be used by the creation of new production units, especially livestock units, and the proper employment of labour.

Post-War Changes

Since World War II, development of new land in southern Australia has proceeded rapidly. The first steps in this expansion were taken during the war when Governments began planning for the settlement of returned servicemen on the land. The knowledge had recently become available to enable previously neglected country in higher rainfall areas to be brought into production, and Governments were faced with the problem of the repatriation of large numbers of young men returning from war service. Expansion of pasture areas under War Service Land Settlement has made a tremendous contribution to land development in the last 10 years. This activity is now past its peak and, although it still plays a very important part, development by private enterprise has increased so much that it is of at least equal significance. In the future, this type of land development will probably have accounted for much greater areas of new pastures, in southern Australia. It will certainly be the case in South Australia.

New areas have been and are being developed in South Australia, Western Australia, Tasmania and Victoria. In addition, much land which was but poorly productive before has now been re-examined and improved. The areas in which development has taken place are generally characterised by good to high rainfall, with an assured growing season of at least six months, and soils of low inherent fertility. This overall similarity has led to the use of tools for pasture establishment which are very much the same throughout most of southern Australia — superphosphate, trace elements (especially copper and zinc) and the strain of subterranean clover most suited to the particular area. Differences, of course, do occur—the use of perennial pasture species is limited in Western Australia, while in Victoria and Tasmania they have a wider application than in those areas of South Australia where most development has taken place. Different clearing problems have had to be overcome in different areas, according to the nature of the vegetation to be removed.

In South Australia increased areas have been recorded under sown pasture each year since the war, averaging over 100,000 acres per year until 1951-52. A change in the method of collecting the statistics last year prevents a valid comparison being made with 1952-53, but this rate has been at least maintained. Not all of the increase has taken place in the areas of new land development where virtually virgin land is handled. Most of it—probably 70-75%, as near as one can judge from the figures—does fall into this category, but the balance represents the development of old lands in the traditionally cereal growing regions.

Again, since the war, there has been greatly heightened interest in livestock farming and the provision of better class pastures in the wheat belt of South Australia. This has had three main effects, (1) the adoption of a sounder land-use system, based on wider cropping rotations and attention to the principles of soil conservation, (2) marked increases in farmers' incomes, largely due to high wool prices but also the improvement in the prices received for livestock products generally. This, of course, has been the strongest motive behind the widespread adoption of livestock farming, and (3) as a result of fertility-retaining and fertility-increasing methods associated with the presence of livestock on the farm, cereal yields have shown a definite upward trend in the last decade.

This upward trend in yields is strikingly shown by the figures for average yield per acre of wheat for South Australia. The average yields in decades since 1860, are shown in Table I.

TABLE I.
Average wheat yields.

Decade	Bushels per Acre
1861-71	9.9
1871-81	8.1
1881-91	6.1
1891-1901	4.7
1901-11	9.2
1911-21	10.5
1921-31	10.0
1931-41	10.6
1941-51	13.0

These figures tell an interesting story of trends in land utilisation. From 1860 to 1900, one sees wheat cultivation extending from the assured rainfall areas of long growing period to drier areas and the depletion of soil phosphate, capped by a run of very dry years in the 1890's. Then came superphosphate and improved drought-resistant varieties; yields recovered and stabilised at between 10 and 10.5 bushels per acre. After the last war, a marked upward trend is seen and, from the figures so far recorded, in the 1950-60 decade, this trend will undoubtedly be maintained.

What are the explanations of the present upward trend? Firstly, the tackling of the marginal lands problem, with the

consequent reduction of cropping in these low producing areas. The diversion of other drier areas to barley has also served to concentrate the State's wheat acreage in the better areas.

Secondly, the improvement of soil fertility by the building up of phosphate levels and the establishment of legumes and pasture grasses, fitting in with wider crop rotations and the carrying of livestock.

Thirdly, the excellent range of varieties now available, enabling those types best suited to a particular district to be grown and the risk of losses from disease virtually eliminated.

And fourthly, better management practices, largely applying to the timing of both seeding and harvesting operations. Modern methods and materials for weed control must also be mentioned.

Old land development in the wheat belt is bringing sound land-use, increased returns from livestock and greater wheat yields from the smaller areas grown. That this upward trend is likely to continue is shown by the yields for the last three years—16.9, 22.0 and 17.9 bushels per acre. Admittedly, the seasons have been good, but previous good seasons have never before produced yields like this.

Turning now to consider some of the economic factors producing this interest in livestock production which underlies both new and old land development, the fundamental fact is the changed relationship of the prices received for cereals and for animal products. If the pre-war prices are taken as the base, it is readily seen that the animal products have left the cereals well behind. Wool, of course, dominates the picture and, at its peak prices, during 1950-51, was returning more than three times the return by cereals compared with pre-war. Other animal products, particularly the meats, show completely different price relations from wheat and the other grains, and these economic factors have made the widespread development of pastures possible.

Employment of Labour

The livestock production which has been taken up has, however, very largely been of the less intensive type—sheep for wool and beef cattle. The more demanding forms of production have not made the same expansion—fat lamb, dairying, poultry and pig raising. The substantial increase in labour-saving machines and devices available to Australian farmers since the war, together with the shortage of labour, have tended to make us relatively less dependent on labour. It has made the farmer seek the mechanically skilled man rather than traditionally trained employees and the effect has been to check the growth of proper employment of labour on Australian farms.

This leads me to pose the question: Are we inclined, in our anxiety to use labour-saving devices on farms, to neglect thinking in terms of the proper employment of labour and the full use of our land and climate?

In Great Britain, the two have gone hand in hand. Traditionally, British farmers have known how to employ labour profitably and well, developing a greatly diversified productive pattern. Nevertheless, the mechanical age has come to United Kingdom farms and, while retaining the full employment of labour, with specialist workers responsible for individual enterprises on the farm, great use is being made of machine aids. C. R. Kelly, 1951 Nuffield Farmer, gives a detailed example of this in his report. The permanent employment on the particular farm of 1,100 acres, cited by him, was as follows:

1 overseer
10 tractor drivers, each with a tractor
1 lorry driver
1 mechanic
1 shepherd
1 pig man
1 head poultry man
3 boys on poultry
1 storeman
4 oddjobbers
1 secretary

making a total of 25 in all. This impressive labour force used an extensive range

of machines, including a number of self-propelled units, in addition to the 10 tractors.

The produce of the farm included barley, wheat, oats, sugar beet, linseed, pasture grass seeds, hay and straw, in addition to production from poultry, pigs and sheep.

In Australia, we have become so used to running 3,000 acre farms with 2 or 3 men that this sort of system seems quite fantastic. In some cases such areas are run by "a man and a dog". A psychological resistance to the smaller types of production has been built up in Australia. The sheep farmer in the south-east of South Australia would not consider setting up a pig or poultry enterprise and putting on a man full time to run it. It would be beneath his dignity and would lower his social status to take on dairy cows. He retains his position in a socio-autocracy by remaining a sheep farmer and perhaps adding beef cattle to his farm livestock.

The point is that there is as yet no real pressure on him to force him to change his way of life to utilise his land resources more fully. This is a young country, underpopulated, and we are still finding large areas for primary development. But our population is growing—and it is doubtful if we can continue to cram people into the sprawling capital cities—and new land will not always be available for development. It is appropriate that we should at this stage take stock of our land resources.

Some Questions and Problems

It is surely high time that we asked ourselves the following question. Are our efforts, in terms of intensification by farmers and facilities on poor country, paying the same dividends that might follow the intensification of similar efforts on older settled lands, particularly in the better rainfall areas? Cannot both developments take place together? If not, then on what should we concentrate? It is Australian tradition to develop more and more rather than intensify and consolidate. Nevertheless, pioneering cannot continue indefinitely.

Concentration these days is on livestock production, and carrying capacity is measured in terms of sheep per acre.

Consider now, for example, the development of 1,500 acres of new country in the Coonalpyn Downs of South Australia, where it is frequently necessary to enclose 1,500 acres to get 100 acres of good pasture with a potential carrying capacity of $1\frac{1}{2}$ sheep per acre. This means that the mean potential carrying capacity of the property as a whole is 1 sheep per acre. The costs per acre of development are as follows:

1.	Price of uncleared land	£2 — £4
2.	Clearing and seed bed preparation	£3 — £3/10/-
3.	Fertiliser (2 years)	£1/15/-
4.	Pasture seeds	£1/10/-
5.	Fencing	£3/10/- — £4
6.	Watering	15/- — 20/-
7.	House and sheds	£3 — £4
	Total — £15/10/- to £19/15/-	

Let us now compare this with the cost of improving production in the cereal districts. It is estimated that in South Australia a mean increase in carrying capacity of $\frac{1}{2}$ sheep per acre could be achieved on many cereal farms by improving the standard of pasture. The outlay required to produce this is as follows:—

1.	Pasture seeds	10/- — 15/- per acre
2.	Additional fertiliser ..	10/- per acre
3.	Fencing and watering .	20/- — 30/- per acre
	Total — £2 to £2/15/- per acre	

This means that an additional sheep can be carried for the outlay of £4 to £5/10/-, as compared with £15/10/- to £19/15/- for the new land. Furthermore, such an improvement in pasture would lead to increased wheat yields, estimated at an average of 3 bushels per acre. The cost of maintaining this higher rate of production would be considerably lower than in the case of Coonalpyn Downs country. Less superphosphate would be required while other costs, like stock handling and fodder conservation, would be equal on both types of land.

In the higher rainfall areas, the improvement of old pasture, frequently comprising subterranean clover, annual grasses and weeds, would cost from £5 to £7 per acre. This is made up of £3 to £3/10/- per acre for seed bed preparation and sowing, from 8/- to 30/- for perennial grass seed and 30/- to £2 for further fencing and watering. The return from a cash crop which could be incorporated in such a renovation programme, has not been taken into account, but there is good evidence that it would be of the same order as the total outlay. The increase in carrying capacity to be expected is from ½ to 1 sheep per acre. Again the returns from the development of "old" country compare more than favourably with those obtained from new land. The cost of maintaining this extra production would be less than in the case of the Coonalpyn Downs country; the smaller amount of fertiliser required being the critical factor.

These examples show a very marked difference between the costs incurred in two types of old land development on the one hand, and new land development on the other, in each case yielding much the same increase in production. Why, then, has there been such a concentration of effort on new country when it would appear that the same increase in livestock production might be attained much more quickly and at much lower expenditure.

The reasons are complex and varied. First, there is lack of knowledge. Too little attention has been paid by the research worker to the problems of secondary development. Some of the major needs at present are:

(a) Strains of legumes and grasses, and particularly of perennial species for the better rainfall areas, adapted to minor or local variations of environment. An active Australia-wide plant breeding programme is needed so that there are strains adapted to all the interactions of soil and climate. There is also a need for strains capable of off-season production, to minimise seasonal fluctuations in the animal's diet.

(b) A better knowledge of pasture management, so that the greatest return of animal produce may be obtained from the herbage. The waste of feed under present management practices is tremendous.

(c) Information on the most profitable method of land use compatible with the maintenance of fertility. The length of the pasture term, the type and number of crops and the breeding of suitable crop varieties for the higher rainfall areas and the integration of mixed stock husbandry are some of the main features.

(d) Data concerning the value of supplementary irrigation in areas of relatively high rainfall, particularly in relation to the more intensive forms of agriculture.

(e) Work on the control of insect pests. This is a most important factor in southern Australia. The severity of red-legged earth mite and lucerne flea attacks on pasture seedlings in the South Australian wheat belt emphasises the point.

Secondly, in many cases there is still a large gap between research findings and farmer action, due to inadequacy of extension services. A good example of this is the large area of country in the South Australian cereal belt which is capable of growing excellent barrel medic, but at present does not. This state of affairs is largely attributable to the inability of a small advisory staff to contact the large number of farmers in the suitable districts.

In the third place are the economic factors, the most potent forces directing development to new land. There is no real pressure on the average farmer on old land to develop the production of his farm to the maximum. High prices, and the high incomes they have brought, have

made most farmers content to coast along. A comfortable living has been obtained without the additional effort and problems of labour management involved in an attempt to approach full land utilisation and full production.

The high purchase price of old land has made it difficult for the man with limited capital resources to make a start in this class of country. The development of new land has been a more attractive proposition to firms or individuals with large profits from industry or a profession. The outlay involved is considerably less than that required to purchase a developed property and furthermore, it is distributed over a number of years. This fact, coupled with the liberal taxation deductions which may be claimed on account of land development, means that those having excess profits to dispose of can budget for a regular annual expenditure to suit their particular circumstances.

There is thus a powerful series of what might be called secondary economic factors in favour of new land development and a lack of information on secondary land development both at the research and the farmer level. These continue to direct the attention, which we might expect to be devoted to the development of old land, on the basis of the costs involved, towards the uncleared acres of our undeveloped country.

As agriculturists we should be fully aware of what is taking place, and while we may have little chance of forcing changes in the particular circumstances at present favouring new land development, there is no reason why we should not recognise the need and advocate the desirability of intensification of production on old lands. Almost unwittingly present policy is forcing the development of unproductive scrub lands and the nation is, through income tax concessions, subsidising the work. It also offers similar concessions, and is consequently prepared to subsidise greater intensification of production on old lands.

In the long term new land development is most desirable. The day must come when every acre capable of producing economically must make its contribution to Australia's income. But in the short term, one is forced to question whether the present concentration of effort and capital on existing farms would not yield richer immediate dividends.

In any event, one problem must be faced sooner or later, on both old and new land—the problem of secondary development. Here is something for us to do. We must see that we find the knowledge of how to handle the secondary phase of the development of cereal and pasture areas, we must see that all farmers are informed of the results of our researches, and we must keep the public aware of the neglected potential that exists on most existing farms. When the time comes, and the secondary phase is forced upon us, let us be sure we have the agricultural answers to the innumerable questions that will arise.

TECHNICAL PAPERS

THE PRESERVATION OF TOMATO SPOTTED WILT VIRUS BY VACUUM DRYING

By K. W. FINLAY and C. A. PARKER

Summary

Experiments were carried out to find a simple method for preserving tomato spotted wilt virus, in order to facilitate selection of resistant phenotypes in hybrid tomato populations.

The virus survived vacuum drying when the infective plant sap was mixed with fresh egg albumen, but it was found necessary to include phosphorus pentoxide in the ampoules to increase the longevity of the active virus.

Using this method the virus was still infective after being stored for 21 months at room temperature.

Introduction

It has been shown by Finlay (1953) that there are five genes in tomatoes for resistance to tomato spotted wilt (T.S.W.), and that each gene controls resistance to a group of T.S.W. strains. At least one strain from each group should therefore be used in inoculation of clones of hybrid progenies, to ensure the selection of resistant phenotypes.

The T.S.W. virus, being one of the most unstable plant viruses known, is perpetuated experimentally by serial inoculation from one susceptible host plant to another. Individual strains must also be carried on in this manner, with the ever-present danger of contamination by other strains or viruses. This entails the use of insect-proof cultural facilities, and also the experienced knowledge of individual strains, so that contaminants may be recognised. These facilities are not usually available to the practical plant breeder, and also the method is time consuming and costly in material.

Bald and Samuel (1934) have shown that inactivation of T.S.W. virus is caused mainly by rapid oxidation on exposure to air, and that the addition of a reducing agent, such as sodium sulphite, retards the inactivation process for several hours. Best (1937) found that when stored in sealed tubes in the presence of cystein and in the absence of oxygen, the virus was active after 35 days storage at 1°C.

Serum proteins and other biological materials, including microorganisms, have been dried and stored *in vacuo* for long periods without appreciable loss of properties (Greaves, 1946). Preservation of bacterial cultures and some viruses is now standard practise in many laboratories. It seemed possible that the unstable, oxygen sensitive T.S.W. virus might be preserved in the desiccated state in the absence of oxygen. The following experiments were conducted to test this possibility.

Methods of Desiccation and Inoculum Preparation

The apparatus used in this study was modelled on that described by Gray (1946), modified by placing the silica gel desiccating agent in a separate cylinder (2″ x 12″), between the vacuum pump and the cylinder carrying the ampoules. The latter were blown from $\frac{1}{4}$ inch sodium glass tubing, and contained about 0.6 ml. suspending fluid when the bulbous portion was filled. At first the ampoules were constricted in the centre before the addition, by means of a Pasteur pipette, of the material to be dried. In the later experiments the cotton wool plugs were pushed down towards the bulb, after a preliminary drying, and desiccating agents were added. The ampoules were then constricted, replaced on the vacuum desiccator, evacuated and finally sealed under vacuum with a small gas flame.

Young tomato leaf tissue in which symptoms of a normal field complex of

K. W. FINLAY, Ph.D., B.Sc. (Agric.) is a Research Fellow and C. W. PARKER, B.Sc. (Agric.) is a Research Officer at the Institute of Agriculture, University of Western Australia.

the T.S.W. virus had recently appeared was used to obtain the inoculum. The tissue was macerated in a mortar with a phosphate buffer at pH 7.0 to which sodium sulphite had been added (Best and Samuel 1936). These were measured to give a 1:10 inoculum. About 0.4 ml. (3-4 drops) of this was placed in each of the glass ampoules, and several 0.4 ml. aliquots of the remaining fresh inoculum were inoculated on half-leaves of *Nicotiana glutinosa* which had previously been dusted with fine carborundum dust. These plants were used as controls.

The ampoules were then evacuated, the suction being controlled at first to prevent undue bubbling of the liquid. After 5-6 hours drying they were sealed off under vacuum, labelled and stored at room temperature. Ampoules were opened as required, and the dried material reconstituted by the addition of 3-4 drops of the original buffer solution. When as much as possible of the dried material had been dissolved, the resultant fluid was used to inoculate half-leaves of *N. glutinosa* dusted with carborundum dust. Daily checks were made for the development of virus symptoms.

Preservation of T.S.W. Virus

Twenty-two ampoules containing T.S.W. infective plant sap were dried by maintaining them at a pressure of 0.5 mm. Hg. for 5 hours. The dried sap from 11 of these ampoules was redissolved and inoculated on to half-leaves of *N. glutinosa* the following day. No lesions resulted from the dried material.

Proteins and protein derivatives have been used to improve the recovery of bacterial cultures after drying (Gray, *op. cit.*, Proom and Hemmons, 1949). A series of treatments which included equal volumes of protein solutions in the raw sap were tested. The results are shown in Table I.

The ampoules were maintained on the vacuum drier for 5 hours at 0.5 mm. Hg. and the contents were dried without freezing. The contents of two ampoules were inoculated immediately (undried) on to *N. glutinosa* as controls. The ampoules of dried plant-sap were redissolved in buffer solution the following day and inoculated on to half-leaves of *N. glutinosa*.

TABLE I.

The effect of the inclusion of proteins on the maintenance of infectivity of T.S.W. inoculum during vacuum drying.

Substance added to sap before drying	Mean number of Lesions per half-leaf 10 days after inoculation
5% gelatin	—
50% fresh egg albumen	9
25% fresh egg albumen	10
12½% fresh egg albumen	—
10% peptone	—
25% milk + 1% $CaCO_3$	—
Controls (not dried)	12

Table I shows that the 25 per cent. and 50 per cent. egg albumen treatments were the only ones which survived drying and remained infective. The virus activity did not differ significantly from the controls estimated as numbers of lesions produced on half-leaves.

Longevity of Dried T.S.W. Virus

A further group of ampoules containing infective plant sap plus 25 and 50 per cent. egg albumen were produced as in the previous experiment to check the viral infectivity of the product over a period of time. The results in Table II show that although the virus survived the treatment as in the previous experiment, it was completely inactivated at the end of one week.

TABLE II.

The effect of different concentrations of fresh egg albumen in maintaining infectivity of T.S.W. virus after vacuum drying.

Per cent. albumen added in equal volume with plant sap before drying.	Mean number of lesions per half-leaf. Time of inoculation after drying	
	1 day	7 days
25	16	—
50	14	—
Control (not dried)	20	—

Another experiment was designed in an attempt to prolong the activity of the dried T.S.W. virus. Considerable amounts of both oxygen and water would be present in the sealed ampoules at the pressures used, and dryness is important for the maintenance of protein materials in good condition (Greaves op. cit.). This principle was later confirmed for a bacterial preparation (Hutton et. al. 1951). Accordingly it was decided to include desiccating agents in the ampoules to reduce the moisture content. The infective plant sap was treated as in the previous experiment with 25 per cent. egg albumen. Half the ampoules contained silica gel granules and half phosphorus pentoxide (approx. 0.1 gm. per ampoule) separated from the dried sap by the cotton wool plug. The results of inoculation the following day and at 21 months are recorded in Table III. The two controls used at 21 months were: plants inoculated with tap water to check leaf abrasion are shown as control (water) and plants inoculated with 0.4 ml. aliquots of inoculum made from fresh T.S.W. infected leaves are shown as control (fresh virus).

TABLE III.

The effect of added desiccants upon the longevity of vacuum dried T.S.W. virus.

Desiccant added to ampoule.	Mean No. of lesions per half-leaf. Time of inoculation after drying	
	1 day	21 months
Phosphorus pentoxide	17	15
Silica gel	18	—
Control (water)	—	—
Control (fresh virus)	12*	22*

*Freshly prepared inoculum.

Although all sap treatments were infective the day after drying, only the fresh virus controls and the ampoules containing P_2O_5 were infective after 21 months.

Discussion

The results in Table III show that the activity of the T.S.W. virus when dried at reduced pressure in the presence of 25 per cent. egg albumen and P_2O_5, was similar to that of fresh inoculum. No direct comparison could be made with either the original control, owing to the change in environmental conditions at different times of the year (Hutton and Peak, 1951), or with the final control (fresh virus) which would almost certainly have a different virus concentration. The fact that no direct comparison could be made, however, does not influence the finding that T.S.W. virus was still infective after being stored at room temperature for 21 months.

Further trials can now be carried out to test the longevity of individual strains of T.S.W. virus when preserved in this way. As the symptoms produced on *N. glutinosa* after 21 months storage appeared to be identical with those recorded for the original control plants, it would appear that all the strains of the original virus complex survived the treatment.

The preservation of T.S.W. virus in glass ampoules which can be stored at room temperature for extended periods provides a much-needed tool for the study and practical breeding of T.S.W. resistance in tomatoes.

Acknowledgments

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THE INSECT VECTORS OF *CLAVICEPS PASPALI* IN QUEENSLAND

By R. F. N. LANGDON and B. R. CHAMP

Summary

The insect vectors of paspalum ergot have been determined. The fly, *Pyrellia caerulea*, which ingests conidia and voids them with its faeces, is the most important insect concerned in the spread of ergot disease in southern Queensland.

Introduction

The heavy and widespread infection of *Paspalum dilatatum* Poir. with *Claviceps paspali* Stev. & Hall which occurs each year in south-eastern Queensland indicates that some efficient vector of the fungus is operating. The conidia, embedded in the sticky honey-dew which exudes from infected plants, are not adapted for wind dispersal. But the sugary honey-dew is attractive to insects, and dispersal of the conidia by insects might be expected.

Stager (1910) reported that a big variety of insects visited ergot honey-dew, and he assumed that they were important agents in spreading the disease. Mercier (1911) found that a fly, *Sciara thomae* L., carried large numbers of conidia of *Claviceps purpurea* (Fr.) Tul. in its intestines, and that many conidia were voided with the faeces. The dissemination of conidia of *Claviceps paspali* by insects in U.S.A. was suggested by Brown (1916), following his observation that insects fed on honey-dew, and Marchionatto (1937) made a similar suggestion about Paspalum ergot in the Argentine. Neither of these workers reported any experimental work on the relation between insects and the spread of ergot.

An investigation of the insects associated with ergot-infected plants of *Paspalum dilatatum* was made during the summer and autumn periods of 1951 and 1952. The objects of the work were to determine those insects which were vectors* of conidia, and their role in the spread of ergot.

R. F. N. LANGDON, M.Agr.Sc., Ph.D., is Senior Lecturer in Botany at the University of Queensland, and B. R. CHAMP, B.Agr.Sc., is Assistant Entomologist, Department of Agriculture and Stock, Queensland.

Materials and Methods

For the collection of insects, stands of *Paspalum dilatatum* heavily infected with ergot were swept with a hand net as the operator walked quickly through the grass. Also, hand collections were made to obtain insects which it was desired to examine for the presence of conidia on external parts. Swept insects were useful only for the examination of intestinal contents and faeces because they were very liable to external contamination with honey-dew from infected inflorescences.

Examination of external parts was made by first viewing the insect through a low-power binocular microscope to seek for gross amounts of conidia-bearing honey-dew, and then washing the insect in water on a slide and viewing the drop with a standard microscope. Conidia, if present, were readily detected. The presence of ingested conidia was detected by dissection of the insect to withdraw the hind gut. Teasing of this organ in a drop of lacto-phenol/cotton-blue revealed conidia if they were present. Faeces were examined by suspension in a droplet of lacto-phenol/cotton blue.

The viability of conidia from the gut and from faeces was determined by incubation of the conidia at 25°C., using the standard slide and petri dish method.

**Vector* is used here to designate an insect which transports conidia.

TABLE I.

Numbers of insects carrying conidia in the gut.

	Nerang 9.3.52	Chermside 25.3.52	Nerang 30.3.52	Redcliffe 9.4.52
DIPTERA				
Musciinae,				
Pyrellia caerulea Wied.	78	14	23	35
Phaoniinae (sp. indet)	16	—	1	6
Fanniinae (sp. indet)	1	—	—	2
Calliphoriinae (sp. indet)	3	1	2	1
Sarcophagiinae (sp. indet)	2	1	—	2
Tachiniinae (sp. indet)	—	1	—	—
Lauxaniidae (sp. indet)	1	—	—	—
Sepsidae (sp. indet)	1	—	1	—
Tetanoceridae (sp. indet)	—	2	—	—
HYMENOPTERA				
Vespidae,				
Rhopalidia gregaria Sauss.	2	1	—	1
Ichneumonidae,				
Paniscus spp.	2	2	—	1
Lissopimpla semipunctata Kby.	—	—	1	—
Braconidae	—	1	—	—
ORTHOPTERA				
Tettigoniidae	1	—	—	—
LEPIDOPTERA				
Crambidae	—	—	1	—

TABLE II.

Viability of conidia ingested by insects.

Source of conidia	Percentage germination of conidia	
	gut	faeces
Pyrellia caerulea	82, 80, 78	85, 90, 82
Phaoniinae (sp. indet.)	74, 81, 84	75, 84, 76
Calliphoriinae (sp. indet.)	82, 80, 80	88, 81, 85
Rhopalidia gregaria	84, 77, 83	80, 85, 85
Infected *Paspalum dilatatum*	85, 82, 79	

Determination of Vectors

Insects collected during three sweeping traverses of 15 yards each were examined for ingested conidia. The numbers of insects found carrying conidia are given in Table I. These numbers correspond with the totals of each species taken.

A few of the following were caught by net sweeping, but none carried conidia internally: Coleoptera (Chrysomelidae, Coccinellidae, Phalacridae), Hemiptera (Jassidae, Membracidae, Cixiidae, Pentatomidae (nymphs only)), Orthoptera (Blattidae, Acridiidae), and Arachnida.

Conidia were found on external parts of the following: Thysanoptera (2 spp.), Orthoptera (Acridiidae, Tettigoniidae), Coleoptera (Coccinellidae), Hemiptera (Aphididae), Hymenoptera (Formicidae) and Arachnida.

To determine the viability of conidia voided with the faeces, certain insects collected from infected Paspalum were caged in glass tubes where they deposited faeces. Germination tests of conidia from this source, from the gut of these insects, and from infected plants were conducted. The results are recorded in Table II.

From the data available, it is evident that *Pyrellia caerulea* is by far the most abundant vector associated with infected plants. Conidia, which it ingests, are voided in the faeces with their viability unimpaired. Certain other insects are also vectors with a potentiality for depositing inoculum on plants, but their numbers are small in comparison with *P. caerulea.*

Transmission of Ergot Disease

Pyrellia caerulea, a metallic green fly about 8 mm. long, has been found in all stands of infected *Paspalum dilatatum,* feeding on honey-dew. If disturbed this fly moves to a neighbouring plant, alighting on any convenient part, but soon returning to the inflorescence to feed or rest. No apparent preference for an infected plant was observed, and young, healthy (though susceptible) inflorescences, as well as infected ones, were visited in random fashion. Faeces are passed up to five times an hour, and food is regurgitated periodically. Both processes result in the deposition of conidia if the flies have previously fed on honey-dew.

Flies fed on honey-dew were transferred to cages where they were given diluted commercial honey. For up to seven days after their last meal of conidia-bearing exudates, flies were found to pass faeces containing viable conidia.

Conidia passed in faeces retain their viability for some time. Flies which had been feeding on honey-dew were held in glass-walled cages for 12 hours and then removed. Triplicate samples of the faeces deposited on the glass were tested for viability of conidia. The percentage germination of conidia after various periods is shown in Table III.

Infection of *Paspalum dilatatum* was achieved when known vectors were caged on susceptible inflorescences. Aphids, which carry inoculum only on their bodies, and *Pyrellia caerulea,* which passes conidia in its faeces, were used.

TABLE III.

Viability of conidia in faeces.

No. of days elapsing	1	2	3	4	5	6	7	10	14
Percentage germination— (a)	83	24	18	18	9	10	13	8	4
„ „ (b)	77	25	35	20	12	10	9	8	3
„ „ (c)	75	28	18	17	10	6	14	17	6

Aphids collected from infected plants were checked visually for the presence of honey-dew on their legs. They were then caged for two hours in large glass tubes on inflorescences of *Paspalum dilatatum* which were undergoing anthesis. After removal of the insects, the plants were kept in a greenhouse. After a week ergot developed. Control plants remained healthy. Similarly, ergot developed when *Pyrellia caerulea* was used as the test insect.

In further tests, faeces deposited by *Pyrellia caerulea* were checked for the presence of conidia and placed on inflorescences of *Paspalum dilatatum* at the time of anthesis. A fine spray of water was applied to the inflorescences and the plant was kept in the greenhouse. After a week ergot developed in inoculated inflorescences. Control inflorescences remained healthy.

Discussion

The vectors of paspalum ergot are divisible into two groups, (a) those which carry inoculum only on external parts of their bodies, (b) those which ingest conidia.

The first group includes some vectors which are only chance visitors to paspalum, e.g., the larger Orthoptera and the Arachnida. Thrips and aphids, moving about on an inflorescence might carry inoculum between florets and so aid in the intensification of the disease in individual plants.

The second group includes a number of strong-flying insects, predominant among which is *Pyrellia caerulea.* This fly occurs in large numbers, and its habits are those which would result in widespread dissemination of inoculum.

The heavy infections with ergot that occur in *Paspalum dilatatum,* and the ubiquity of *Pyrellia caerulea* with its proven capacity as an effective vector support the conclusion that *Pyrellia caerulea* is the most important insect concerned in the rapid spread and widespread occurrence of ergot disease in south-eastern Queensland.

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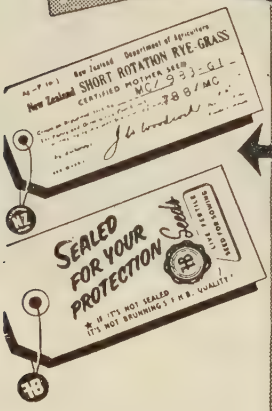

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THE EFFECT OF CALCIUM SULPHATE ON THE RESPONSE OF SUBTERRANEAN CLOVER TO ROCK PHOSPHATE

By K. D. McLACHLAN

Summary

The results of a pot culture experiment designed to test the effects of rock phosphate and calcium sulphate on subterranean clover (*Trifolium subterraneum*, L.) are presented. The soil used was acid, and deficient in phosphorus and sulphur.

Calcium sulphate had only a small effect on the yield of clover. Its effect on the nitrogen content was considerable. The data indicate that the actual level of sulphate was more important than the sulphur : phosphorus ratio. The evidence also suggests that adjusting the sulphur : phosphorus ratio to that in superphosphate might decrease both the yield and percentage nitrogen of the clover.

The effect of rock phosphate differed at different levels of calcium sulphate. In the absence of calcium sulphate rock phosphate increased the yield of clover, but markedly decreased the percentage nitrogen in the clover. Where calcium sulphate had been applied, the rock phosphate increased both the yield and the percentage nitrogen in the clover.

The percentage and total amount of phosphorus in the clover was greatest where calcium sulphate had been applied with the rock phosphate.

Introduction

Rock phosphate has been tested at many centres in Australia, always in comparison with superphosphate. In general, it has been regarded as an unsatisfactory phosphatic fertiliser.

Since the recognition of sulphur deficiency in Australian soils (Anderson and Spencer, 1949), it has been shown that this soil deficiency is widespread geographically and commonly occurs in association with phosphorus deficiency (McLachlan, 1953, 1954).

The object of the present experiment was to examine the effect of rock phosphate alone and in the presence of calcium sulphate on subterranean clover when grown on a soil known to be deficient in both phosphorus and sulphur (Anderson, 1952).

Experimental

The pot culture experiment was commenced on June 4, 1952. Glazed earthenware pots were filled with 1.7 Kg. of oven dry soil and sown with inoculated seed of the Bacchus Marsh variety of subterranean clover. The soil was a grey brown sandy clay loam, pH 6.4, of granitic origin, collected near Crookwell, N.S.W. The pots were watered to weight (field capacity) frequently. The tops were harvested on September 29, 1952, oven dried and weighed.

The phosphate used was Nauru rock phosphate which contained 4.41 per cent. neutral ammonium citrate soluble phosphorus. The particle size of this material was such that 81.4 per cent. passed through a 200 mesh sieve.

The rock phosphate was applied at seven levels corresponding to the total phosphorus dressing in 0, 2, 4, 8, 16, 32 and 64 cwt. of superphosphate per acre. The three calcium sulphate levels corresponded to the total sulphur dressing in 0, 2 and 4 cwt. of superphosphate per acre. Sodium molybdate, at the rate of 2 oz. per acre, was applied as a basal dressing. The treatments applied to the pots were:—

Rock phosphate, nil, 0.16, 0.33, 0.66, 1.32, 2.65 and 5.30 g. per pot.

Calcium sulphate, nil, 0.18 and 0.37 g. per pot.

K. D. McLACHLAN, B.Sc.Agr., B.Comm., is a Senior Research Officer in the Plant Nutrition Section, Division of Plant Industry, C.S.I.R.O., Canberra.

A simple factorial design was used to test the treatments which were applied in the dry state and mixed in the top two inches of soil. There were six replicates of each treatment.

Total nitrogen determinations were made on the finely ground oven dried material. The ammonia from the final distillation was trapped in 2 per cent. boric acid solution as described by Ma and Zuazaga (1942).

Results

(a) Effect of Treatment on Yield.

The effect of treatment on the yield of subterranean clover is shown in Table I. The statistical analysis of the yield data was based on transformed values. The transformation used was log $(x + 2)$.

Under both conditions rock phosphate significantly increased the yield of clover. The greatest increase in yield occurred when calcium sulphate, at the rate of 0.18 g. per pot, was applied with the rock phosphate. The main effect of rock phosphate on yield was significant at $P < 0.001$.

Calcium sulphate had less effect on yield. The main effect on yield, however, was significant at $P < 0.001$. At the highest rate of application, calcium sulphate tended to depress the yield of clover at low levels of rock phosphate. At higher levels of rock phosphate this trend was diminished.

The interaction of rock phosphate and calcium sulphate on yield was significant at $P < 0.05$.

(b) Effect of Treatment on Percentage Nitrogen and Yield of Nitrogen in the Plants.

The effect of treatment on the percentage nitrogen in subterranean clover is shown in Figure 1.

Treatment with rock phosphate alone significantly decreased the percentage nitrogen. In the presence of calcium sulphate, treatment with rock phosphate increased the percentage nitrogen in the clover. The regression slopes for the curves representing the low and high levels of calcium sulphate were significantly different ($P < 0.01$). Rock phosphate increased the percentage nitrogen most where calcium sulphate at the rate of 0.18 g. per pot, the low level, had been applied with the rock phosphate. Further increase in the level of calcium sulphate increased the percentage nitrogen only at the lower levels of rock phosphate. The rock phosphate-calcium sulphate interaction on percentage nitrogen was significant at $P < 0.001$.

TABLE I.

Effect of rock phosphate and calcium sulphate on the mean yield of subterranean clover (g/pot D.M.)

Rock phosphate g. per pot	Calcium sulphate, g. per pot		
	0.00	0.18	0.37
0.00	3.2 (0.71) *	3.9 (0.77) *	3.2 (0.72) *
0.16	5.7 (0.88)	5.9 (0.89)	4.5 (0.81)
0.33	7.0 (0.95)	8.5 (1.02)	6.6 (0.93)
0.66	9.1 (1.04)	10.1 (1.08)	9.6 (1.06)
1.32	11.1 (1.11)	13.6 (1.19)	13.3 (1.19)
2.65	13.3 (1.18)	15.7 (1.24)	15.1 (1.23)
5.30	16.8 (1.27)	17.5 (1.29)	16.1 (1.29)

Sig. diff. for $P < 0.05$ (0.04)
Sig. diff. for $P < 0.01$ (0.06)

*Figures in brackets are the transformed values.

The effect of treatment on the yield of nitrogen is shown in Figure 2. Treatment with rock phosphate alone or in the presence of calcium sulphate significantly increased the yield of nitrogen in subterranean clover. The main effects of rock phosphate and calcium sulphate on nitrogen yield were significant at $P < 0.001$ and $P < 0.01$ respectively. The optimum yield of nitrogen was obtained where calcium sulphate at the rate of 0.18 g. per pot was applied.

As for percentage nitrogen, the regression slopes of the nitrogen yield curves for low and high levels of calcium sulphate were significantly different ($P < 0.05$). Over the range of rock phosphate dressings applied, calcium sulphate at the low level (0.18 g. per pot) has had the greater effect on nitrogen yield. The rock phosphate-calcium sulphate interaction on nitrogen yield was also significant ($P < 0.001$).

Discussion

The percentage phosphorus in the clover plants was determined according to the method of Zinzadze (1935) on the bulked material of the six replicates. Increasing the level of rock phosphate applied increased the percentage phosphorus in the clover plants, but the addition of calcium sulphate resulted in still greater uptake of phosphorus by the plants. In the presence of rock phosphate, calcium sulphate increased both the percentage and yield of phosphorus in the plants. The absorption of the phosphate was not adversely affected by the presence of sulphate (Bear, 1950).

Increasing the level of rock phosphate applied had the greatest effect on the yield response of subterranean clover. The effect of calcium sulphate on the yield response by subterranean clover to dressings of rock phosphate was small. Under field conditions this effect might pass unobserved. The effect of the sulphur on the yield in this experiment may have been partly restricted by phosphorus deficiency, due to the low rate of availability of the phosphorus in the rock phosphate. For in a concurrent experiment, superphosphate treated plants yielded 140 to 180 per cent. more dry weight than those treated with the same amounts of phosphorus and sulphur as rock phosphate and calcium sulphate.

The calcium sulphate effect on percentage nitrogen and the yield of nitrogen in the clover was marked. Rock phosphate alone decreased the percentage nitrogen

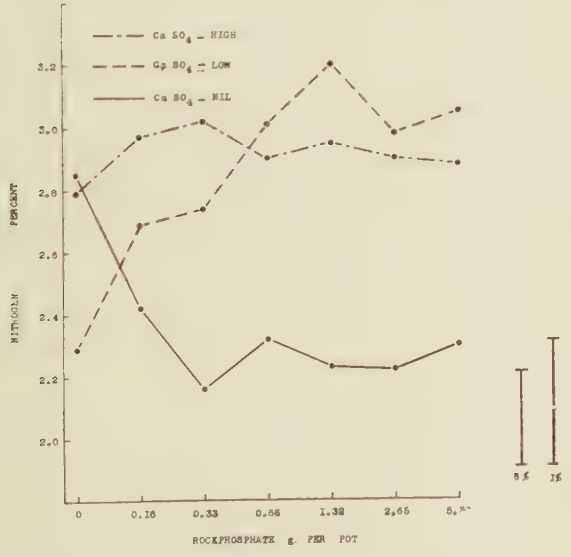

Figure 1.
Effect of rock phosphate and calcium sulphate on percentage nitrogen in subterranean clover.

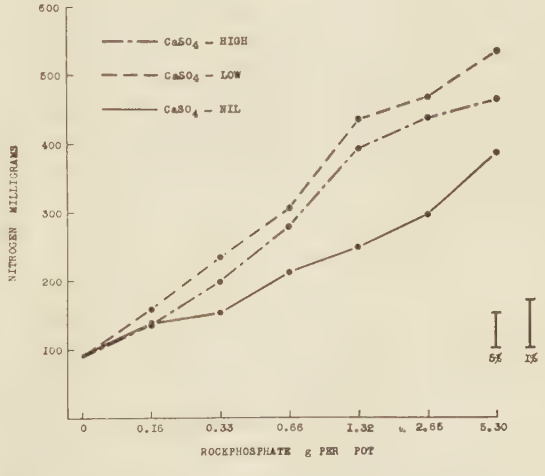

Figure 2.
Effect of rock phosphate and calcium sulphate on yield of nitrogen in subterranean clover.

in the clover plants. Where calcium sulphate had also been applied this effect was reversed. This increase in percentage nitrogen implies increased protein formation (Anderson and Spencer, 1950).

The evidence presented suggests that the effect of the calcium sulphate in increasing the yield and percentage nitrogen was due to the sulphur in this fertiliser. Where calcium sulphate had not been applied, increasing levels of calcium applied in the rock phosphate were associated with a marked decrease in the percentage nitrogen in the clover. This indicates that calcium was not involved in the effect of calcium sulphate. It is known (Anderson and Spencer, 1950) that sulphur applied to a soil deficient in sulphur increases the yield and percentage nitrogen in clover, as did the calcium sulphate, and, further, that the soil used in the present experiment was sulphur deficient. Again, in a concurrent trial, sulphates of sodium, iron, magnesium and calcium all significantly increased the yield of clover ($P < 0.01$). Calcium sulphate was no more effective in increasing the yield than were the other sulphates.

In a previous study (Trumble and Shapter, 1937), an increase in the level of phosphate did not increase the percentage nitrogen in the clover. In their experiment a basal dressing of sodium sulphate, providing sulphur equivalent to approximately $7\frac{1}{2}$ cwt. superphosphate per acre, was used. The present experiment shows that the effect of phosphorus on percentage nitrogen may vary with conditions. Variation in the sulphur supply may reverse the effect of phosphorus. There may well be a critical level of sulphate for attaining optimum percentage nitrogen in subterranean clover. It is apparent that the application of rock phosphate and calcium sulphate, at levels of phosphorus and sulphur equivalent to that in a dressing of superphosphate, results in a lower percentage nitrogen than where a smaller dressing of calcium sulphate was used.

It is evident that even where calcium sulphate has little effect on the yield of subterranean clover, it may have a marked influence on the way in which rock phosphate affects the quality of the plants. In fact the effect of phosphate on quality may be reversed by the use of calcium sulphate.

Acknowledgment

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TECHNICAL NOTES

DIFFERENT MOLYBDENUM REQUIREMENTS OF MEDICS AND SUBTERRANEAN CLOVER ON A RED BROWN SOIL AT WAGGA, NEW SOUTH WALES

In a field trial at Wagga, New South Wales, established by C.S.I.R.O. in co-operation with the New South Wales Department of Agriculture, subterranean clover (Bacchus Marsh) and various species and strains of annual medics were sown to determine their production and capacity to build up soil nitrogen. The soil on which the trial is located can be broadly described as a red brown earth, but is atypical in that there is no free lime in the profile. It has a pH of 5.7 in the top 4 in.

Subterranean clover grew well, and the associated Wimmera rye grass was healthy in appearance and vigorous, while the wheat crop which followed three years' growth of this legume/grass association had a healthy green appearance, all indicative of active nitrogen fixation by the legume.

On the other hand the medics rapidly lost vigour after the first year, the plants yellowed during the winter time and many of them died, apparently from an infection of *Ascochyta imperfecta* (black stem). Both the Wimmera rye grass growing with the medic and the wheat crop following the medic were yellow and unthrifty, apparently indicating unsatisfactory build up of soil nitrogen by the legume. Yet where subterranean clover volunteered on the medic plots and the plants were intermingled, the clover leaves were green and healthy in appearance, although the admixed medic leaves were yellow and unthrifty.

It was observed that the yellowing and dying of the medics varied between and within species, e.g., *M. tribuloides* Desr. was less affected than *M. hispida* Gaertn. while *M. hispida* Gaertn. *reticulata* Urb. and *M. hispida* Gaertn. *terebellum* Urb. suffered more than *M. hispida* Gaertn. *denticulata* Urb.

The yellowing of the medic herbage showed up on the oldest leaves and was most pronounced towards the periphery of the leaves, and in the intraveinal areas. On badly affected leaves, tissues along the margins became brown and necrotic. Some of the leaves were puckered, and there was a general reduction in leaf size.

An examination of the root systems of discoloured medic plants showed a good development of healthy pink nodules and rhizobium isolates from these were tested and found to be quite effective in fixing nitrogen in the test tube. A field application of molybdic acid was made on

TABLE I.

Response by Medicago hispida reticulata growing on red-brown earth from Wagga, N.S.W., to applications of molybdenum and nitrogen.

Yield of oven dry herbage (g. per pot)

Treatment	Without Nitrogen	With Nitrogen
Without molybdenum	0.520	0.934
With molybdenum	1.074	1.232

3/7/53 at the rate of 2 oz. per acre. This caused the yellowed medic plants to develop a normal green colour and to grow vigorously, but appeared to have no effect on the subterranean clover.

On 24/7/53 a pot trial with the soil from the experimental site was established at Canberra using *M. hispida reticulata* strain No. 10. Applications of molybdenum and nitrogen were given and the responses to each of these elements indicated that the molybdenum supply to the medics growing on this soil was insufficient for active nitrogen fixation (see Table I).

Molybdenum was applied at rate of 4 oz./ac. as sodium molybdate and nitrogen at 23 lb./ac. in the form of ammonium nitrate.

The mean effect of nitrogen is significant at the 5 per cent. level and of molybdenum at the 1 per cent. level.

It would thus appear from these field observations and pot culture responses that for active growth and nitrogen fixation medics have a different molybdenum requirement to subterranean clover and it is not unlikely that the inability of medics to flourish on certain acidic soils where subterranean clover can be readily grown may be due partly to insufficient molybdenum for the medics. That the adaptability of medics to the more alkaline soils is largely a consequence of a more readily available supply of molybdenum and/or other elements required for nitrogen fixation is an interesting possibility. Further work on the varying molybdenum requirement of these species is proceeding.

W. D. ANDREW
R. T. MILLIGAN
Division of Plant Industry,
C.S.I.R.O.,
Canberra, A.C.T.

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THE RELATIONSHIP OF MEAN THICKNESS AND ITS RANGE IN AUSTRALIAN MERINO WOOL

Considerable attention has been given to the measurement of wool fibre thickness, because of its direct and indirect associations with many of the more important wool characters. In addition to direct measurement by microprojection methods, there have been alternate approaches by such methods as the micrometer (Burns and Koehler, 1925), porous plug (Cassie, 1942), Weight - length (Roberts, 1930), optical interference (Ewles, 1928), sedimentation of fibres in a liquid medium (Le Compte, 1948), and the "photometric measurement of a projected area of fibres viewed perpendicular to their length" (Giovanelli, 1947). Notwithstanding these developments, the direct microprojection method is most favoured in serious routine measurements. The samples for microprojection may be in the form of cross-sections or of "length-profiles" (of about 1 mm. length). Hardy and Wolf, 1939, have indicated rapid methods of estimating fineness and cross-sectional variability, by means of a count of the number of cross-sections contained within a given area at a known magnification, due regard being paid to the density of packing of the sample. Information has been gathered in the hope that a similar rapid method of estimation might be found for "length-profiles". Unfortunately this has not been found practicable, owing to the dispersion of the profiles when mounted, compared with the compactness of a cross-sectioned sample.

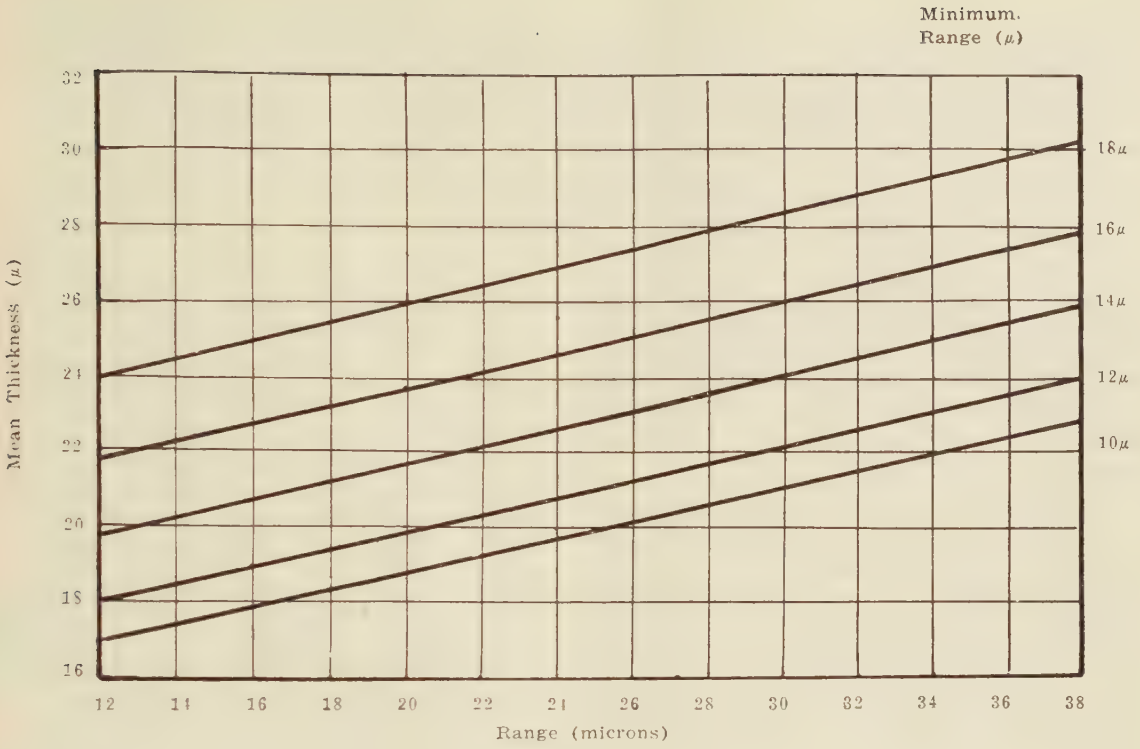

Figure 1

Relationship of Mean Thickness and Range for Merino wool of a wide range of mean thickness and variability. Mean thicknesses when grouped according to the minimum thickness show an approximately linear increase with increasing range.

However, some of this information may be useful to other workers in the field, and for this reason the relationship of mean thickness and its range has been reported herein.

2,671 different merino staples of a wide variety of quality number and type have been included. 250 measurements were made on "length-profiles" mounted in Euparal, the approximate length of the fragments being 1 mm. When mounted these were in equilibrium with an atmosphere of 65 per cent. relative humidity and 67.5 deg. F. temperature. Samples were degreased in cold benzene and later mixed in light petroleum having a boiling point range of 40-79 deg. C. From Figure 1 it will be observed that when the mean thicknesses are arranged in order of equal minimum fibre thickness of the distribution (10, 12, 14, 16 and 18μ), the means increase approximately linearly, with increase in the range.

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W. R. LANG.

Textile College,
Gordon Institute of Technology,
Geelong, Vic.

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THE GROWTH OF *ERYSIPHE GRAMINIS HORDEI* ON SUSCEPTIBLE AND RESISTANT VARIETIES OF BARLEY

Barley leaves infected with powdery mildew were subjected to a clearing and staining process used for observing nematodes in plant tissues (Goodey, 1951) and it was found that details of both the mildew fungus and host cell reactions could be observed.

The process consists of immersing the leaf in a 0.1 per cent. cotton blue lactophenol solution in a beaker and bringing it to the boil over a bunsen flame and allowing it to simmer for three minutes. The leaf is allowed to remain in the solution until it is cool and it is then rinsed in water to remove excess stain and mounted in clear lactophenol on a slide.

Using this technique a comparison was made of the rate of growth of the mildew fungus as well as the number of haustoria formed by a colony on susceptible and highly resistant varieties of barley. Because damaged or killed host cells stained blue, it was also possible to observe the reaction of both the infected epidermal cells and the mesophyll beneath the infection courts on these varieties.

To obtain quantitative data, daily counts were made, after inoculation, on twenty colonies, each derived from a single conidium, on at least three leaves of both susceptible and highly resistant hosts. The number of hyphal cells formed per colony in 24 hours was used as a measure of growth rate and the means of these observations during the four days following inoculation are shown graphically in figure 1. The digitate haustoria are readily distinguishable and, though not staining as deeply as the remainder of the fungal tissue, could be counted in the epidermal cells beneath each colony. The means of these on both hosts are also represented graphically in figure 1.

It will be seen that the growth rate of the pathogen is limited by the number of haustoria formed. On the susceptible host the number of haustoria that developed permitted a progressive increase in growth rate of hyphae, whereas on the highly resistant host only one haustorium was formed by each colony (very rarely two were formed) during the four days following inoculation, with the result that the growth rate of hypae fell off after the second day to zero by the fourth day.

When the reaction of the tissues to infection in these two hosts was studied it was found that the inhibition of development of haustoria on the highly resistant host appeared to be due to mesophyll collapse rather than to collapse of the infected epidermal cells, the generally accepted explanation (Cherewick, 1944, Smith 1938). In highly resistant hosts it was found that two days after inoculation a mean of six mesophyll cells had collapsed beneath each infection court. By the end of four days a mean of fourteen mesophyll cells had collapsed as seen in figure 2. In the susceptible host there was no mesophyll collapse during the four days following inoculation, nor was there any collapse in the mesophyll of these hosts even after seven days from inoculation.

It is concluded that successful establishment of the powdery mildew fungus on barley, as measured by mycelial development and ultimately by conidial formation, is conditioned by the number of haustoria formed by the colonising fungus in the infection court. This in

turn appears to be directly related to the rate and degree of mesophyll collapse beneath the infection court.

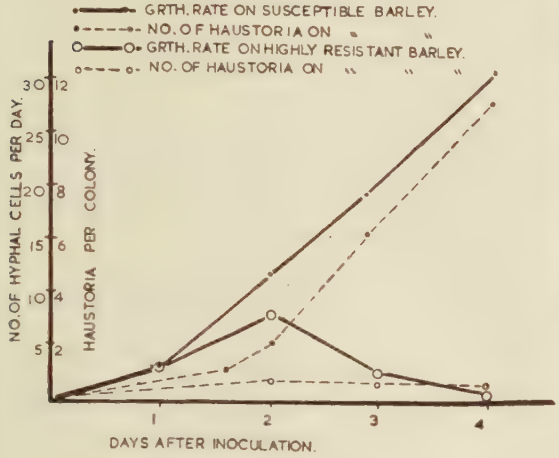
GRTH. RATE ON SUSCEPTIBLE BARLEY.
NO. OF HAUSTORIA ON " "
GRTH. RATE ON HIGHLY RESISTANT BARLEY.
NO. OF HAUSTORIA ON " " "
NO. OF HYPHAL CELLS PER DAY.
HAUSTORIA PER COLONY.
30 25 20 15 10 5
12 10 8 6 4 2
1 2 3 4
DAYS AFTER INOCULATION.

Figure 1.
Growth rate and number of haustoria formed by colonies of Erysiphe graminis var. hordei on susceptible and highly resistant barley varieties.

A detailed account of this investigation, embracing host-pathogen studies on semi resistant, and resistant varieties of barley will be published elsewhere in the near future.

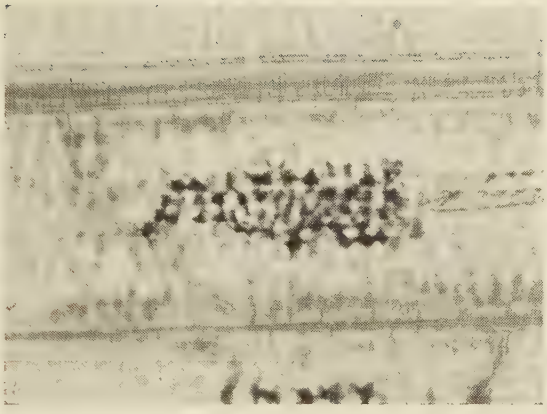

Figure 2.
A photomicrograph of collapsed mesophyll beneath the infection court of a highly resistant variety of barley after clearing and staining with hot lactophenol cotton blue. x150.

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N. H. WHITE,
Plant Pathology Laboratory,
Faculty of Agriculture,
University of Sydney.

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COUNCIL PROCEEDINGS

Result of Central Secretariat Vote.

The unconfirmed Minutes of the 137th Meeting of the Council of the Institute state that on the 27th May, 1954, Mr. V. K. Lohmeyer, Returning Officer, declared the referendum carried with the following voting returns:—

State	In Favour	Against	Ineligible	Total
A.C.T.	34	8	4	46
N.S.W.	55	26	2	83
Queensland	37	25	2	64
S.A.	26	55	—	81
Tasmania	25	7	1	33
Victoria	178	21	7	206
W.A.	35	22	—	57
Total	390	164	16	570

Informal: 1.

An application has since been made to the Department of Commerce and Agriculture for an allocation of funds from the Commonwealth Extension Services Grant.

The position of "Executive Officer" to organize and administer the affairs of the Institute is advertised under "Appointments Available" on Page 136 of this Journal.

PORTABLE EQUIPMENT FOR THE FIELD DETERMINATION OF SOLUBLE SALTS IN SOILS

Recently Aitchison (1953) has described a portable resistance measuring bridge designed essentially for the field determination of soil temperature and soil moisture. The bridge* is also ideally suited to the determination of soluble salts by conductivity. It uses a reed hummer as a source of 1,000 c/s, A.C. voltage and a microammeter to detect the null point. Although the single dial is graduated to indicate directly the common logarithm of resistance over the range 10^2 to 10^6 ohms, it is most accurate between 10^3 and 10^5 ohms.

*Commercially available from National Instruments Pty. Ltd., Sydney.

Two methods are in current use for making soil/water mixture suitable for conductometric determination of soluble salts; one uses a fixed ratio of soil to water, e.g., 20 g. soil and 100 ml water and the other uses just sufficient water to

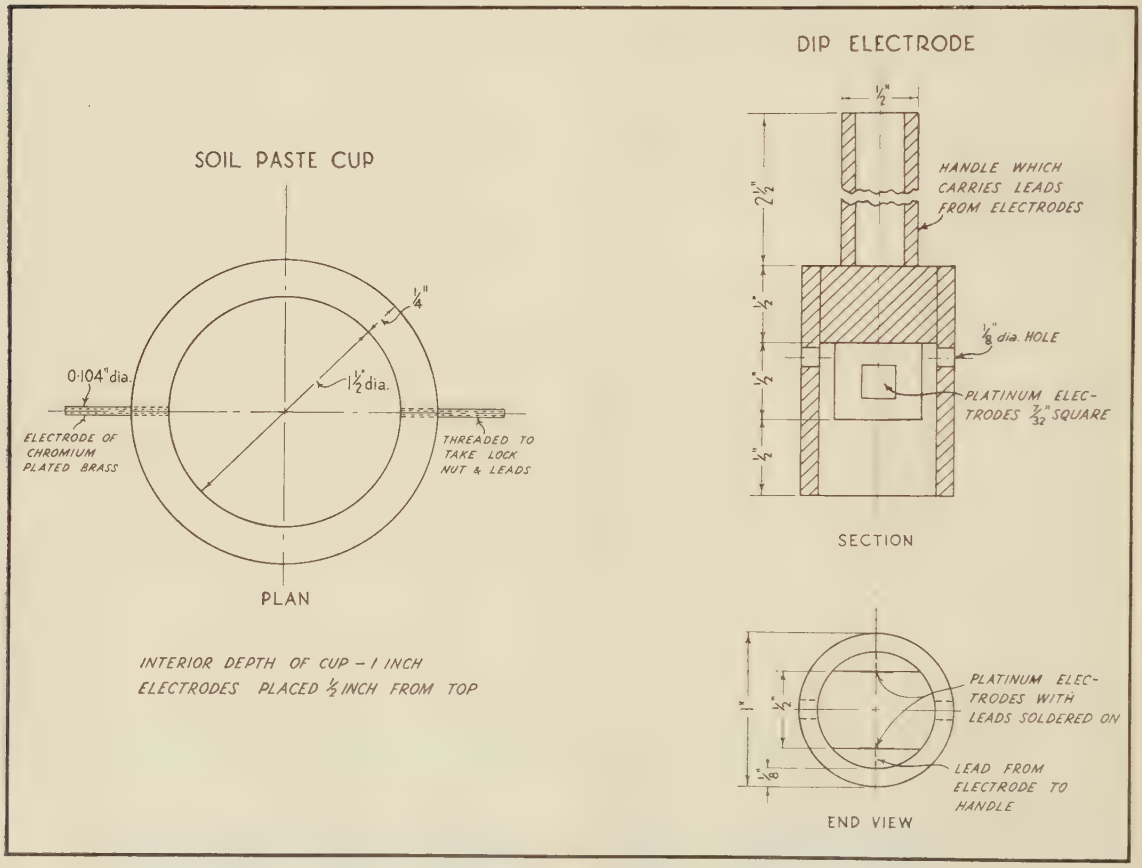

Figure 1.
Conductivity cells for field use.

make a saturated soil paste. This latter method is most convenient for use in the field in that no weighings or volume measurements are required and is recommended by the Soil Survey staff of the U.S. Department of Agriculture (1951), but the conversion of resistance to salt content is more complicated. A dip type of conductivity cell is most suitable for the first method as it can be used to assist in stirring the soil/water suspension, while an open cup type is most suitable for the paste method. Polystyrene, because of its mechanical strength and high insulation, is a very suitable material for the fabrication of the cells and the dimensions of two suitable cells are shown in Figure I. The size of the electrodes and their distance apart have been specified so that each cell has a resistance of between 10^3 and 10^5 ohms for soils with salts ranging from 1.0 to 0.01 per cent. Calibration of the dip cell is straightforward and a nomogram is most useful for rapid conversion of resistance to salt content. For the cup using soil pastes the conversion factor varies with both salt content and texture of the soil. Factors are available in the U.S.D.A. Soil Survey Manual (op. cit.) or they may be ascertained by using soils of a known salt content, determined by conductivity of a 1 : 5 soil water suspension.

The constructive comments of Messrs. G. Blackburn and A. R. P. Clarke, who have used these cells in the field (1953) have been most welcomed and the assistance of the Workshop of the Division in making the cells is gratefully acknowledged.

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Blackburn, G. and Clarke, A. R. P. (1953)—C.S.I.R.O. Division of Soils—Unpublished Records.

J. T. HUTTON.

Division of Soils,
C.S.I.R.O.,
Adelaide, S. Aust.

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INSTITUTE AFFAIRS

COUNCIL PROCEEDINGS

The 136th meeting of the Council of the Institute was held at the School of Agriculture, University of Melbourne, on 11th and 12th March, 1954. All branches except South Australia were represented by delegates in person.

Present:—Dr. I. F. Phipps (President, in the Chair), Mr. W. J. S. Sloan (Queensland), Prof. P. R. McMahon (N.S.W.), Mr. C. S. Christian (A.C.T.), Mr. R. G. Downes (Victoria), Mr. D. S. Thompson (Tasmania), Prof. G. W. Leeper (proxy for S.A.), Mr. H. G. Cariss (W.A.) and Mr. H. P. C. Trumble (Hon. General Secretary).

Central Secretariat

This was the main item for discussion at the meeting, which began with a review of developments by the President.

The Central Secretariat is an attempt to overcome the difficulties which the Institute has encountered as it has grown to the size where it can no longer properly manage its own affairs by voluntary efforts alone. The proposal has been under consideration by the Institute for several years.

The possibility of obtaining finance to launch this scheme was realised in 1953 as a result of the efforts of Dr. A. R. Callaghan who was President at the time. It then became necessary to alter the Articles of Association to enable the Institute to employ paid staff. Prior to the 21st General Meeting, all members were circularised and provided with proxy voting papers so that they might be represented at the General Meeting. They were also sent documents which set out the history and financial and other implications of the Central Secretariat proposal, together with a case for it and a case against it.

As a result of the votes cast at the General Meeting, the Articles of Association were amended to enable the Institute to employ paid officers. At the meeting, however, Dr. H. G. Andrewartha (S. A. Branch), as the holder of more than 10 proxy votes, demanded a postal ballot, under Article 66 of the Articles of Association. A compromise was reached on the basis of the modified wording of a subsequent motion instructing Council to examine the setting up of a Central Secretariat and, if satisfied, to proceed; an assurance that there would be no undue haste in Council's deliberations was also given to Dr. Andrewartha.

The date suggested for a Council meeting to consider the Central Secretariat was considered by Dr. Andrewartha to be too soon (one month was suggested) after the General Meeting and to meet his objection, the meeting was called for 10th and 11th March.

In the meantime, a second demand for a postal ballot to confirm the amendment to the Articles had been received from Mr. D. S. Riceman, President of the South Australian Branch, under Article 78 of the Articles of Association. During subsequent correspondence between himself and the President, Mr. Riceman suggested that the South Australian Branch would on certain conditions be prepared to withdraw its demands for a postal ballot on the Articles of Association, which required a majority of all members entitled to vote to vote in favour of the amendment to the Articles. The conditions were that Institute members be consulted as to their preference for the establishment of a Central Secretariat as envisaged by the Victorian Branch or for part time paid clerical assistance, up to a maximum expenditure of £750 per annum on salaries.

The South Australian attitude was based upon the belief that many of the members voting at the 21st General Meeting had voted in favour of the amendment to Article 46, but were not in fact in favour of the establishment of a Central Secretariat under the amended Articles. The Branch therefore believed that Council should not proceed to establish a Central Secretariat without further reference to the membership of the Institute.

Delegates from all Branches except South Australia were emphatic that, to their knowledge, the two issues were firmly linked in members' minds and that the vote in favour of the amendment of Article 46 could justifiably be interpreted as a vote in favour of the establishment of the Central Secretariat.

Prolonged discussion took place amongst the delegates, and finally the following resolutions were passed:

"This Meeting of Council expresses itself as being in agreement with the resolutions carried by the 21st General Meeting under Item 9: Other Business, viz.:—

"That this Meeting views with favour the establishment of a Central Secretariat and recommends to Council that it be given serious consideration. If the Council is satisfied, it is empowered to give effect to the proposal.

"If the Council decides to proceed to establish a Central Secretariat, that it takes into consideration the draft outline of duties and functions, as circulated to members before this meeting, together with the following suggestions:—

(a) That the title of the executive officer be reconsidered.

(b) That duties (iii) and (iv) be amended to read:

'(iii) To undertake special enquiries as directed by Council and to be responsible for the preparation of fully-documented reports to assist

in the formulation of Institute opinion on matters under consideration. In so doing, to seek authoritative advice from members and, as appropriate, to be directed by sub-committees appointed by Council.

(iv) As directed, to prepare for the consideration of Council press or other public statements expressing the views of the Institute on issues of concern to the welfare of agriculture or to the profession of agricultural science, such statements to be issued by the President and in his name.' "

It was then proposed by Mr. Christian, seconded by Mr. Downes that:

"Having examined all aspects of the amendment of Article 46 of the Articles of Association and the establishment of a Central Secretariat which have been presented to it, Council is of the opinion that the voting at the 21st General Meeting on the amendment of the Articles of Association did truly represent Institute opinion but it accepts the view that there may be reason for the doubt expressed by the South Australian Branch as to the validity of the voting on the subsequent motion, recommending that Council proceed with the establishment of a Central Secretariat if, after examination of the position, it is satisfied. For this reason, Council considers that the matter may best be resolved by submitting to a referendum of members the question of the establishment of a Central Secretariat along the general lines proposed in the document accompanying the case for and the case against the amendment to the Articles of Association, the main features of which are:

(i) the acceptance of the proposed Commonwealth grant;

(ii) the employment of a senior executive officer together with clerical assistance;

(iii) the executive officer to fulfil the functions of the present Hon. Business Manager of the Journal and such other duties as directed by Council and;

(iv) the scheme to involve a total annual cost of about £4,000."

The details of the referendum and of the documents to accompany the ballot paper were then agreed upon.

Australian Medal of Agricultural Science

The by-laws governing the award of this medal were amended to provide for a Recommending Committee to take the place of the original system of Branch Committee voting. Branches were asked to suggest the names of persons considered suitable as members of the first Recommending Committee.

Continuity of Services of the President

Various means of extending the period of service of the President to the Council of the Institute were discussed, including the provision of a two-year term, eligibility for immediate re-election and *ex-officio* service. It was pointed out that any of these possibilities would require amendment of the Articles of Association and the matter was referred back to Branches for further discussion.

A.J.A.R. Distribution Account—Managership

The resignation of Mr. W. Ives from this position, on account of his imminent departure for England, was accepted with regret and Mr. P. F. Butler appointed in his stead.

Membership

Admissions to Corporate Membership.

With the recommendation of the Branch Committees concerned and the favourable report of the Qualifications Committee, the following were admitted to corporate membership:

Davern, C. I., Australian Capital Territory
Haantjens, H. A. „ „ „
Nutman, P. S. „ „ „
Jessup, R. J., New South Wales
Lukins, B. G. „ „ „
Stannard, M. C. „ „ „
Jones, E., Queensland
Teakle, D. S. „
Aitchison, G. D., Victoria
Millis, N. F. „
Edwards, B. A. B., Western Australia.

Student Membership.

With the recommendation of the Victorian Branch Committee the following was admitted to Student Membership:

Thomas, D. A., Victoria

Resignations.

The resignations of the following members were accepted with regret:

Brewer, R., Australian Capital Territory
Nicholson, A. J. „ „ „
Bancroft, L. J. (Miss) New South Wales
Carn, K. G. „ „ „
Carter, H. B. „ „ „
Lukins, B. G. (Mrs.) „ „ „

Terminations.

Acting on the recommendation of the Branch Committees concerned, the following had their membership terminated:

Robertson, F. R. (Mrs.) New South Wales.
Evans, A. M. Queensland.

Death.

The death of Mr. O. Perkman of the N.S.W. Branch was recorded.

Transfers.

The following inter-branch transfers were noted:—

Coleman, R. G., West Australia to Queensland.
Colquhoun, T. T., South Australia to Australian Capital Territory.
Fisher-Pollard, J., Victoria to New South Wales.
Gardner, F. J., New South Wales to South Australia.

Gibbons, F. R., New South Wales to Victoria.
Holloway, B. W., South Australia to Australian Capital Territory.
Hutton, E. M., Australian Capital Territory to Queensland.
Litchfield, W. H., South Australia to Queensland.
Norris, D. O., Australian Capital Territory to Queensland.
Poutsma, T., West Australia to South Australia.
Pugsley, A. T., South Australia to New South Wales.
Ritchie, W. F., Victoria to New South Wales.

Subscriptions Waived.

With recommendation of the Branch Committees concerned, the subscriptions of the following members were waived for the years stipulated:—

Browning, T. O.	*South Australia*	1953
Edwards, G. R.	*South Australia*	1953
Henzell, E.	*Queensland*	1954
Lawler, T. R.	*New South Wales*	1954
Moore, A. W.	*South Australia*	1953
Russell, J. S.	*South Australia*	1952, 1953

BRANCH NOTES

New South Wales

At the annual meeting of the Branch held on 24th February last the following office-bearers were elected:—

President: Mr. J. M. Vincent.
Vice-President: Prof. P. R. McMahon.
Hon. Secretary: Mr. A. S. Peterson.
Hon. Treasurer: Mr. C. L. Goldstone.
Committee Members: Dr. K. O. Campbell, Mr. K. R. Green, Miss S. W. Hayter, Mr. K. E. Hutton, Mr. W. V. Single, Mr. P. G. Valder.

The meeting, which was held in the conference hall of the Rural Bank, was preceded by a very enjoyable buffet tea. This annual get-together was greatly appreciated by the 43 members and visitors present.

At the general meeting held on 18th March in Sydney members heard an address by Dr. M. C. Franklin on "Animal Production in U.S.A. and Great Britain". During his visit to these countries last year Dr. Franklin was most impressed by the fact that most research workers felt that there was an urgent need to increase world food production. The speaker stressed that we can learn a great deal about animal production from America.

In comparing animal production in Australia and U.S.A. the advantages in climate and transport enjoyed by American pastoralists were pointed out. U.S.A. is also far ahead in fodder conservation. To meet America's expected increase in population an increase in primary production of 40 per cent. will be required by 1965 and this will require the large scale solution of many problems. For example 40 million crop acres will have to be reverted to pasture because of erosion hazards. On the basis of what is being done in the U.S.A. the speaker highlighted, with the aid of lantern slides, the practices which will increase beef production in Australia and stated that there is a great need for more applied research in this country.

In conclusion Dr. Franklin predicted considerable improvement in Australia's beef production methods by better transport, abandoning of old production methods, improved fodder conservation techniques with lower production costs, pasture improvement, feeding of protein concentrates, better utilisation of irrigation water and increased research and extension services.

The Committee of the Branch has for some time been concerned about the poor attendance of members at Branch meetings, even when Institute affairs of some importance have been discussed and when the guest speaker has been most eminent and the subject most stimulating. At times members have almost been outnumbered by visitors. Does this mean that most members are apathetic and just not interested in the affairs of the Institute and the organisation of Agricultural Science? Activity at the Branch level is the basis of healthy development of the Institute and on the activity and standing of the Institute the status in the community of individual members as agricultural workers depends to an important degree.

Queensland

The Annual General Meeting of the Queensland Branch was held on 24th March. The President, Mr. W. W. Bryan, in his Presidential address, discussed the problems associated with the establishment of pasture plants in the wallum lands along the Queensland coast.

Office-bearers of the Queensland Branch for 1954 are as follows:—

President, Mr. W. J. S. Sloan.
Vice-Presidents, Dr. L. G. Miles and Mr. W. W. Bryan.
Hon. Secretary-Treasurer, Mr. B. R. Champ.
Asst. Hon. Secretary-Treasurer, Mr. G. J. McCarthy.
Journal Sub-Editor, Dr. R. F. N. Langdon.
Committee Members, Mr. G. H. Allen, Mr. F. Chippendale, Mr. S. Waring.

The April meeting was devoted to "Notes and Exhibits". Dr. L. G. Miles spoke on the variation in standards for wheat quality in Queensland over recent years. The quality of various wheats was discussed and farinograms and extensograms of several varieties were exhibited. Mr. S. Waring discussed changes in soil moisture

under wheat and under fallow on the Darling Downs. Mr. Dastani gave an account of his researches on drought resistance in sugar-cane.

South Australia

At the Annual General Meeting on 12th March the following office-bearers were appointed:—

President, Dr. R. J. Swaby.

Vice-President, Mr. D. S. Riceman.

Hon. Secretary, Mr. V. K. Iohmeyer.

Hon. Treasurer, Mr. A. J. K. Walker.

Journal Sub-Editor, Mr. B. G. Coombe.

Committee Members, Dr. H. G. Andrewartha, Dr. T. Marshall, Mr. G. Blackburn, Mr. N. S. Tiver.

In delivering his Presidential address, Mr. D. S. Riceman spoke on "Some Nutritional Problems Relating to the Coonalpyn Downs". He outlined the early work leading to the development of this area. It was soon evident the problem was chiefly nutritional.

The area offers little choice of pasture species and most work has been done using Bacchus Marsh strain of subterranean clover with some attention being given to lucerne, Phalaris and Wimmera Rye Grass. The conclusions drawn from complex field trials have been limited by extreme variability in seasonal rainfall. For example, the optimum phosphate dressing may vary widely from year to year and so influence the effects of small additions of zinc and copper. Field experiments have shown clearly that the large area known as Coonalpyn Downs can support highly productive legume and grass pastures. Chemical analysis of these soils has shown them to be extraordinarily low in phosphorus, nitrogen, zinc and copper. Mr. Riceman outlined some of the field experiments which illustrated the nature of the problem and the results which could be obtained. Later work has examined the effect of extremely light and extremely heavy dressings of zinc sulphate on the survival and growth of sub-clover. A comparison was made of the amounts of zinc added as an impurity in superphosphate with that taken up annually by a clover pasture. The effects of competition between sub-clover and lucerne on total production of dried matter in field trials was also discussed.

At a meeting on 9th April, Mr. A. G. Strickland and Mr. G. R. Edwards co-operated in giving an outline on "Some Problems of the Potato Industry".

Mr. A. G. Strickland, Chief Horticulturist of the S.A. Department of Agriculture, spoke first and gave reasons for the high food, news and political value of the potato; it has no substitute that satisfies the consumer; there is no exportable surplus and therefore no buffer to the consumer; seasonal conditions affect production and opportunities are available for sellers to create local shortages. In discussing possible solutions, Mr. Strickland said that Commonwealth control which would guarantee a price, control acreages and take surplus production, would probably not be acceptable to the States. State Potato Boards try to control distribution as far as their powers allow.

South Australia's requirement is about 45,000 tons annually and pre-war was supplied by locally grown potatoes with the spring gap in supplies being filled by imported potatoes. Another aspect of the subject has been the change in varieties, the newer ones are highly productive and disease resistant but have shorter storage life than the varieties grown ten years ago. The desirable objective is for South Australia to be self-supporting in potato production with the spring gap bridged by winter storage. This conclusion led to the second talk on "Potato Storage and Dormancy Investigations" by Mr. G. R. Edwards, Horticultural Research Officer, based on research work carried out in South Australia and continued for 12 months at the University of California, Davis.

Mr. Edwards summarised the various ways of overcoming the spring shortage and explained that besides breeding varieties with a larger storage life, the most likely method was the use of growth regulating substances to suppress sprouting and so prolong the dormant period. He reviewed the experimental work up to 1950 in which quite good suppression was obtained with the methyl ester of alpha naphthalene acetic acid. In 1951, isopropyl phenyl carbamate gave even better results, there being no sprouting during up to 6 months' storage with a subsequent halving of the weight loss in untreated potatoes. Results from California with these two substances were the reverse of South Australian results, so a comparison was made of weight loss during storage of the two treatments at two temperatures. This showed a significant interaction of temperature which might explain this difference.

Mr. Edwards then outlined his work on potato dormancy and the effect of various substances on wound periderm formation. The sprout suppressant substance, I.P.P.C., at higher concentrations, prevented the development of cork cells. MANA had less effect. Two substances known to break dormancy, ethylenechlorohydrin and glutathione, favoured the development of cork cells. These results were discussed in the light of various theories on the initiation and suppression of sprouting.

"Principles of Insect Ecology" was the title of an address given by Dr. H. G. Andrewartha on 14th May. The three factors affecting popula- predatory insect; it had to have powers of development and longevity, have each to be studied under the influence of environment, which in turn can be broken down to four components, weather, food, effect of other animals and the finding of a place in which to live. These effects were discussed with the aid of diagrams and examples, particularly of the effect of predators on populations. Dr. Andrewartha then explained the qualities needed for an effective predatory insect; it had to have powers of development and also powers of dispersal greater than its prey. Examples of successful and unsuccessful predators and the reasons for their failure were used to illustrate these points.

Tasmania

The Annual General Meeting of the Tasmanian Branch was held on 22nd March, 1954, in the Canterbury Tearooms, Hobart. Seventeen members were present and the following office-bearers were elected:—

President, Mr. L. W. Miller.

Vice-President, Mr. E. J. Martyn.

Hon. Secretary, Mr. I. D. Geard.

Hon. Treasurer, Mr. J. R. Ward.

Journal Sub-Editor, Miss E. G. Wingrave.

Publicity Officer, Mr. R. C. Sykes.

Committee Members, Mr. E. F. Fricke, Mr. D. Berry.

Mr. D. Thompson, who had been Acting President since Professor Barber's departure for U.S.A., delivered the Presidential address which was entitled "Fertility in Sheep". This was a comprehensive review of recent work on the subject. Following the address the meeting adjourned for supper.

Victoria

The Annual General Meeting of the Victorian Branch was held on the 28th May, 1954. In his Presidential address, Mr. R. G. Downes discussed the assessment of land for its development, improvement and conservation.

Office-bearers of the Victorian Branch elected for 1954 are as follows:—

President and Principal Delegate, Mr. B. F. McKeown.

Vice-President, Mr. L. L. Stubbs.

Immediate Past President, Mr. R. G. Downes.

Hon. Secretary, Mr. J. A. Roberts.

Hon. Assist. Secretary, Mr. R. O. Kefford.

Hon. Treasurer, Mr. J. V. Mullaly.

Journal Sub-Editor, Miss I. J. Stewart.

Hon. Recorder, Mr. J. J. Lenaghan.

Committee Members, Mr. P. F. Butler, Mr. L. R. Hoult, Mr. T. S. Bellaire, Mr. J. K. Gaunt.

Prof. of Agriculture (ex officio), Prof. S. M. Wadham.

Federal President (ex officio), Dr. I. T. Phipps.

PERSONAL NOTES

Australian Capital Territory

Mr. G. Alan Stewart, Senior Survey Officer of the Land Research and Regional Survey Section of C.S.I.R.O. left Australia recently on an overseas visit. Mr. Stewart will spend about six months in Africa south of the Sahara where he will study soils and their relation to land use. He will attend the International Soil Science Congress at Leopoldville in the Belgian Congo in August 1954 and will also spend about two months in the United Kingdom and Europe.

Mr. H. A. Haantjens will lead the Papua survey unit of the C.S.I.R.O. Land Research and Regional Survey Section. The unit will be in the field from July to September in the Wanigela-Cape Vogel area.

Mr. R. D. Brock has returned to the Division of Plant Industry, at C.S.I.R.O., Canberra, after spending two years at the John Innes Horticultural Institution, Bayfordbury, England, on a C.S.I.R.O. studentship. His work was mainly on the genetical and cytological aspects of failure of hybridisation and reduced fertility in hybrids. While abroad Mr. Brock was a delegate to the 9th International Genetics Congress.

Dr. D. Spencer, Research Officer in the Plant Nutrition Section of the Division of Plant Industry, has been awarded a post-doctoral Fellowship to study in the United States. He left Australia in June to spend twelve months at the McCollum-Pratt Institute of the Johns Hopkins University, Baltimore, where he will be working on the biochemical functions of micronutrient elements in plants.

Recent appointments to the Division of Plant Industry, C.S.I.R.O., Canberra, include *Dr. R. J. Ketallapper, Ph.D.,* a graduate of the University of Utrecht, Holland, who has joined the Plant Introduction Section; *Mr. H. Daday,* a graduate of the University of Budapest, who has joined the Genetics section; *Mr. F. J. Bergersen,* a graduate of the University of Otago, N.Z., to work in the Microbiology Section; *Miss Ruth Stephens,* who has just completed her doctorate at the University of Glasgow, is working as personal assistant to the Chief of the Division of Plant Industry, Dr. O. H. Frankel; *Dr. F. Morley,* until recently Special Veterinary Research Officer of the N.S.W. Department of Agriculture at Trangie, has joined the Genetics Section, also *Mr. G. L. Brown,* formerly Head of the Engineering Section, Defence Research Laboratories, Maribyrnong, has been appointed Divisional Engineer.

New South Wales

Mr. P. G. Valder, a biologist in the N.S.W. Department of Agriculture, has been awarded a very generous "Ben Fuller" travelling scholarship, the first which has become available for some years. He will be leaving for England in August and will be away for two years. Mr. Valder will continue his studies on diseases of pasture plants and will probably work at Cambridge.

Mr. J. H. B. Christian, a bacteriologist in the Division of Food Preservation of C.S.I.R.O., has been awarded a C.S.I.R.O. Overseas Studentship. He will also leave in August and will spend about two years at the Low Temperature Research Station, University of Cambridge, working on the problem of the water relations of bacterial cells.

Miss K. Donovan, who has been working at the University Agriculture School, has been awarded a Walter and Eliza Hall Fellowship. She will be proceeding to Edinburgh in August where she will continue her investigations in the field of the bacteriology of milk.

Queensland

Mr. B. L. Oxenham of the Plant Pathology Section, Department of Agriculture and Stock, will visit New South Wales, Victoria and South Australia during May and June to confer with horticulturists and pathologists on citrus root stocks and their relation to virus diseases of citrus.

Mr. L. M. Rule, a recent graduate in Agricultural Science of the University of Queensland, has been appointed to the Horticultural Branch of the Queensland Department of Agriculture and Stock. He will be stationed at Ayr.

Mr. J. B. Ritson has resigned from the Queensland Department of Agriculture and Stock and is now at the Kimberley Research Station of the Department of Agriculture, Western Australia.

South Australia.

Mr. J. V. Mertin, who was formerly of the Division of Plant Quarantine, Canberra, has taken up an appointment with Houghton and Byrne (S.A.) Ltd., in Adelaide. Mr. Mertin is not employed with Wm. Haughton Ltd. as was reported in the March issue.

Dr. F. L. Milthorpe, Head of the Plant Physiology Department at the Waite Agricultural Research Institute, will hold the newly-established Chair of Agricultural Botany in the Department of Agricultural Sciences at Nottingham University. He plans to leave towards the end of this year.

Prof. C. Donald, former Assistant Chief of the Division of Plant Industry, C.S.I.R.O., has commenced duties as Professor of Agriculture at the University of Adelaide and Head of the Department of Agronomy at the Waite Agricultural Research Institute.

Dr. E. A. Cornish has been appointed Chief of the new Division of Mathematical Statistics of C.S.I.R.O. The headquarters of the Division is in Adelaide.

Mr. H. K. Kemp has resigned from his position as Senior Horticultural Research Officer, S.A. Department of Agriculture, and is now farming.

Mr. D. T. Kilpatrick has been appointed Senior Horticultural Adviser, S.A. Department of Agriculture.

Mr. D. Bockman, formerly of the University of Sydney, has commenced duties as Technical Officer of the Soil Microbiology Section of the C.S.I.R.O. Division of Soils, Waite Institute.

Tasmania

Mr. F. W. Hicks, who is the Superintendent of Technical and Extension Services in the Tasmanian Department of Agriculture, recently left for a tour of the U.S.A. and the United Kingdom. Mr. Hicks will return to Tasmania early in December.

Professor H. N. Barber, who is at present in California, has been involved in a motor accident. However he has now returned to work and is able to get around satisfactorily on only one crutch.

Victoria

Mr. W. Ives has been appointed Chief Scientific Liaison Officer, London, and expects to commence duty at the end of June. He will be overseas for two years.

NEWS ITEMS

Food Technologists Convention

The Fourth Annual Convention of the Institute of Food Technologists in Australia was held at the Ritz Hotel, Leura, N.S.W. on 26-29th May, 1954. About 150 representatives of the food industries and research institutes attended, mainly from New South Wales and Victoria, but other States were also represented. Technical papers were presented on various aspects of food processing and research, with special emphasis on quality control. This year a novel feature of the Convention was an exhibition of modern trends in the packaging of foods. The use of specialised transparent plastic film in packaging is expanding rapidly and has a wide application.

Dr. V. M. Lewis and Mr. S. M. Sykes are active members of the Committee of the N.S.W. Branch of the Institute of Food Technologists and were closely associated with the organisation of the convention. The Institute of Food Technologists is comparatively new but is now well established as a vital force in the various food industries in Australia.

Dr. M. J. D. White

Dr. M. J. D. White arrived in Canberra in September, 1953, to take up appointment as Senior Research Fellow in Cytogenetics at the Division of Plant Industry, C.S.I.R.O. Dr. White was born in London in 1910 and was on the staff of University College, London, from 1933 to 1947. During the year 1937-38 he was at Columbia University, New York, on a Rockefeller Fellowship. Over the period 1947 to 1953 he was Professor of Zoology at the University of Texas, U.S.A. He has also worked at the Department of Genetics of the Carnegie Institution, Washington. During the war, Dr. White served in the British Ministry of Food. He is a specialist on chromosome cytology and the author of two books in this field, "The Chromosomes" and "Animal Cytology and Evolution". Dr. White is particularly interested in cytological variation in natural populations of animals and plants and is continuing this line of work in Australia.

Professor C. M. Donald

The appointment was announced recently of Mr. Colin M. Donald, formerly Assistant Chief of the Division of Plant Industry, as Professor of Agriculture at the University of Adelaide and Head of the Department of Agronomy at the Waite Agricultural Research Institute.

Professor Donald is an Honours graduate in Agricultural Science of the Universities of Sydney and Adelaide. He joined C.S.I.R.O. in 1930 at the Waite Agricultural Institute, since

which time he has been engaged in pasture research. As Assistant Chief of the Division of Plant Industry, he was responsible for the crop and pasture research in the Division in all southern States of the Commonwealth, including the C.S.I.R.O. regional centres from Kojonup in W.A. to Armidale in N.S.W. He was overseas for two years in 1939-41, studying research in the U.K., U.S.A. and New Zealand.

In 1951 Professor Donald was invited by the Organisation for European Economic Co-operation to join an international mission to survey and report on pasture and fodder production in Mediterranean countries. He subsequently engaged in a collecting and exploration expedition in the Mediterranean before returning to Australia.

During the war Professor Donald was Assistant Director of the Department of War Organisation and Industry in charge of the Rural Industries Division. He is one of the authors of a book now being published by the Stanford University of California on the wartime agriculture of Australia.

Mr. T. T. Colquhoun

The appointment of Mr. T. T. Colquhoun, M.Sc., as Commonwealth Director of War Service Land Settlement was recently announced. Mr. Colquhoun, by his appointment, assumes responsibility for the administration of the scheme which is operated by the Commonwealth in co-operation with the various States for the re-establishment of ex-servicemen on the land.

Prior to taking up his present appointment and transfer to Canberra, Mr. Colquhoun was Deputy Director of War Service Land Settlement in South Australia. He went to that position from the Waite Agricultural Research Institute, Adelaide, where he was a Plant Pathologist. Mr. Colquhoun is a foundation member of the Institute, being associated for most of the time since its inception with the South Australian Branch, in which he served as Honorary Secretary and President at various times. On the transfer of "head office" of the Institute to South Australia he became Honorary General Treasurer.

Conference of Fleece Measurement for Flock Improvement

Doubling of the rate of flock improvement in Merino sheep should follow the adoption of techniques considered by a meeting of State and Commonwealth sheep and wool specialists just concluded in Sydney. These techniques are based on fleece measurements which have been shown to be workable under practical conditions.

The Conference was convened by C.S.I.R.O. to consider applying new developments in fleece measurement to flock improvement. Special interest was shown in the progress of early attempts to apply recent research findings, particularly by the Queensland and New South Wales Departments of Agriculture and the New South Wales University of Technology.

The Conference agreed that maximum improvement in the industry as a whole would come from the inclusion of measurement as an adjunct to sheep classing in the parent studs, but the use of these methods would also be desirable at all levels of the industry. Improvement could be effected in two ways—first in the current flock through ewe selection, and secondly by genetic improvement based mainly on ram selection.

Fleece measurement should be used in addition to usual methods based on visual appraisal. The greasy fleece weight obtained at shearing is the main measurement used in ewe selection, but is only an early stage in ram selection. For rams an increased intensity of measurement is required as culling proceeds, and a further elimination is based on clean fleece weight obtained by scouring small samples of fleece. Final choice of rams is based on measurements of staple length and, where practicable, fibre diameter and number. Thus, in following this sequence, the more costly measurements are used only for the relatively few rams involved in later stages of selection.

The limited but successful application of this work in practice has shown that procedures for carrying out these measurements can be adopted with comparative ease in flock management at a cost which is repaid by the benefits achieved. The procedures to be followed in the resultant culling have also been worked out in detail.

The Conference recommended that producers should be encouraged to carry out their own measurements of fleece weight, body weight and staple length. It agreed that more facilities at central measuring centres in some States might be required to meet potential demand. Encouragement should be given to developing cheaper and more rapid measurements of fibre diameter and fibre number.

APPOINTMENTS AVAILABLE

AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE.
EXECUTIVE OFFICER.

An Executive Officer located in Melbourne is required by the Australian Institute of Agricultural Science.

The initial appointment will be for 4 years with a commencing salary at the rate of not less than £1,500 per year.

Duties: To act as the Executive Officer of this Australia-wide body, to organise and administer the affairs of the Institute under terms of policy laid down by the Council of the Institute.

Qualifications: Competence in organisation and administration is required. A training in agricultural science and a knowledge of Institute affairs will be an advantage.

Applications should be addressed to the Hon. General Secretary, Box 901E, G.P.O., Adelaide, South Australia.

PUBLIC SERVICE OF SOUTH AUSTRALIA

Applications for the positions set out hereunder will be received by the Public Service Commissioner, 31 Flinders Street, Adelaide, until and including 2nd August, 1954.

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience, and give particulars of war service (if any). Copies only of testimonials should be submitted with the application.

SALARIES QUOTED ARE ACTUAL AND INCLUDE COST OF LIVING ADJUSTMENTS TO DATE.

Agricultural Department

SENIOR HORTICULTURAL RESEARCH OFFICER

Salary Range: £1,312-£1,417 per annum.

Duties: Supervision of the Research Section of the Horticultural Branch including assistance to research officers on design and interpretation of research projects and the work conducted on five horticultural and viticultural experiment stations.

Qualifications: Applicants must be graduates in Agricultural Science and have had substantial post-graduate experience in horticulture.

HORTICULTURAL ADVISER

(Two positions)

Salary Range: £1,057-£1,147 per annum.

Qualifications: A sound theoretical knowledge of fruit culture; practical experience with the types of trees and vines grown in South Australia, and for one position, familiarity with methods of irrigation and fruit drying.

Applicants should be able to identify common pests, have a knowledge of control methods and the ability to address public meetings.

A degree or diploma in Agricultural Science is desirable.

The appointees may be stationed in a country district.

COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF HEALTH

SENIOR RESEARCH OFFICER, PLANT QUARANTINE SECTION, CANBERRA (THREE POSITIONS).

Salary: £1,154-£1,322 per annum.

Duties: Research and investigation into all technical matters, in the special fields mentioned below, affecting or arising from Plant Quarantine policy under the Federal Quarantine Act 1908-1950.

Qualifications: Degree of an Australian University in Agricultural Science or Science, or an analogous degree of an overseas University of equivalent standing.

Undergraduate training in at least one of the following fields: (a) Entomology; (b) Plant Pathology; (c) Botany — Horticulture is desirable.

Post-graduate experience in research teaching or commercial application in one of these fields is also necessary.

A sound general knowledge of Agriculture, experience in conference work and ability to co-operate with other technical experts are desirable.

Applications (stating age, marital status, war service (if any), qualifications and experience) to:

The Director-General of Health,
Canberra, A.C.T.

by 31st July, 1954.

PUBLIC SERVICE OF SOUTH AUSTRALIA

Applications for the undermentioned position will be received by the Public Service Commissioner, 31 Flinders Street, Adelaide, until and including 2nd August, 1954.

Applicants should state full names, address, date of birth, marital status, academic qualifications, practical experience and particulars of war service (if any). Copies of testimonials should be submitted with the applications.

The appointee may be required to contribute to the Government Superannuation Fund.

Agriculture Department

ADVISER IN ANIMAL PRODUCTION (PIG HUSBANDRY)

Salary range: £1,057/£1,147 per annum (salaries quoted are actual and include cost of living adjustments to date).

Duties: To advise producers on problems of animal husbandry and production by means of addresses, field days and demonstrations, and to prepare articles for general dissemination, with special reference to pig husbandry. The appointee will also be required to assist in the conduct of investigations into the problems of animal production.

Qualifications: Applicants must have at least a Diploma in Agriculture and have had experience in pig husbandry.

APPOINTMENTS AVAILABLE

BUREAU OF AGRICULTURAL ECONOMICS

RESEARCH OFFICER GRADE 1

Salary Range: £962/£1,106.

Duties: Undertake research into economic conditions and problems of wool-growing, including economic surveys and other field investigations.

Qualifications: A University Degree in Agricultural or Veterinary Science essential. Experience in wool industry desirable.

Applications, giving details of qualifications and experience, should be forwarded to the Secretary, Department of Commerce & Agriculture, Canberra, prior to 31st July, 1954.

The successful applicant will be required to take up duty in Canberra at an early date.

AGRONOMIST

THE COLONIAL SUGAR REFINING COMPANY LTD.

has a vacancy for an

AGRONOMIST

at a Sugar Mill in Fiji
Permanent Staff Position

Duties: To carry out foliar analysis and soil survey work in Fiji.

Qualifications: Must have completed an honours course in soils at an approved University and preferably have had 2-5 years experience in soil survey work. Age: 24-35 years.

Salary: In accordance with age and qualifications, but commencing at not less than £1,000 p.a.

Conditions: Accommodation for single or married man. Superannuation Fund. Passages to Fiji provided. Eight weeks' leave every two years.

Applications in writing, with references to:
The Staff Officer,
Box 483, G.P.O.,
Sydney.

THE UNIVERSITY OF ADELAIDE

Applications are invited for the following appointments in the Department of Agronomy at the Waite Agricultural Research Institute:—

1. READER (OR SENIOR LECTURER) IN AGRICULTURAL GENETICS AND PLANT BREEDING.
2. LECTURER IN AGRICULTURAL GENETICS AND PLANT BREEDING.

These two appointments are being made to establish a separate section of Agricultural Genetics and Plant Breeding within the Department. The section will conduct a breeding and research programme on crop and pasture plants of importance in southern Australia. The appointment of the lecturer will be made after that of, and in consultation with, the Reader (or Senior Lecturer).

3. JOHN MORTLOCK RESEARCH FELLOW (with the status and salary of a Senior Lecturer).

It is expected that the Fellow's work will lie in autecological studies of semi-arid areas, but the Fellow will be afforded considerable scope in the definition of his programme.

General: Every potential applicant is invited to obtain from the undersigned a further statement about the posts and a copy of the formal terms of appointment of Readers, Senior Lecturers and Lecturers which, except for paragraph 4 relating to Duties, apply to these appointments.

Salary Scales: Reader—£A1,660—60—1,840.
Senior Lecturer—£A1,360—60—1,600.
Lecturer—£A1,000—60—1,300.

Superannuation: On F.S.S.U. basis.

Applications: Applications, in duplicate, giving particulars of age, academic qualifications, experience, and war service (if any) and accompanied by a recent photograph, a medical certificate of health, a list of publications, copies of testimonials and the names and addresses of two referees of whom confidential enquiries may be made, should reach the undersigned not later than **AUGUST 16, 1954.**

A. W. BAMPTON,
Registrar.

8th June, 1954.

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